

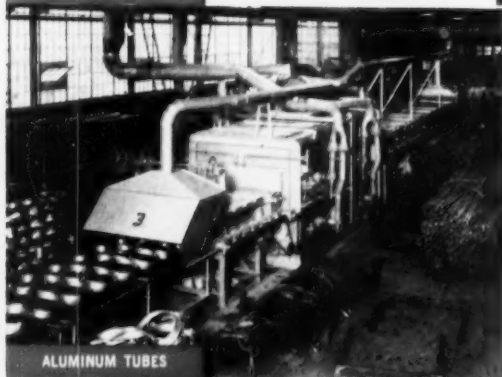


Metal Progress

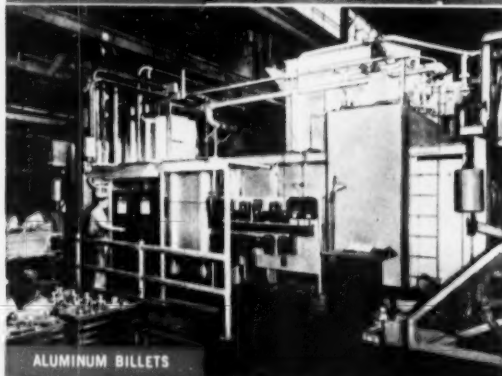
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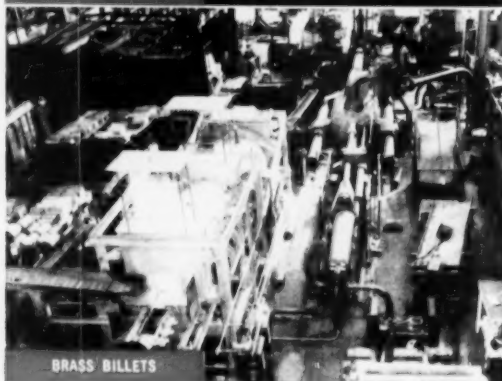
BRASS SLABS AND STRIP



ALUMINUM TUBES



ALUMINUM BILLETS



BRASS BILLETS

*costs trimmed
quality assured*

in tailor-made furnaces for non-ferrous metals

Whatever non-ferrous metals you heat treat—in whatever size or shape—"Surface" engineers can tailor furnaces to fit your production needs. Some of the many custom-built "Surface" furnaces are shown here—others have been used for slab heating, annealing, stress relieving, solution heat treating, ageing, forging, homogenizing, precipitation hardening.

"Surface" furnace engineering is based on years of practical experience, intensive research in metallurgical heating methods, and an almost unlimited variety of furnace and conveyor equipment. "Surface" engineers have worked with the processors of copper, aluminum, and magnesium alloys as well as precious metals; giving them the "right cut" in costs, increased production, improved quality. Write today for Literature Group H53-6, showing "Surface" tailoring for heat treating non-ferrous metals and alloys.



SURFACE COMBUSTION CORPORATION • TOLEDO 1, OHIO

ALSO MAKERS OF

Kathabar HUMIDITY CONDITIONING **Janitrol** AUTOMATIC SPACE HEATING

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•See Bill's Column
on the other side ➔



MERRY CHRISTMAS to all of you from all of us!

Will the few of you who read this column kindly refresh your memories about the predictions I made for the Cleveland Metal Congress and Exposition? If you recall them you'll have to admit I missed them all. I said the Congress and Exposition would be great and now it turns out it was colossal.

But I like to underestimate the effects of events. If they don't pan out you don't have to make excuses, and if they exceed expectations—as they did—you can sit back, relax, relieve the inside tension, and live again.

But this exceeding of expectations is really a triumph for you ASMembers. You did a swell job in your technical sessions, your attendance was perfect, and you may well be proud of another feather placed in A.S.M.'s cap.

The Metal Show was the largest industrial exposition ever held in Cleveland. Clocked attendance for the five days totalled 111,061. The number of registered visitors totalled 50,858 (subject to Metal Show Audit).

The greatest headache was the inadequacy of sleeping accommodations for exhibitors, members and customers. Cleveland has 7162 hotel rooms, of which 3500 were allocated to the Housing Bureau, while the remainder was assigned as the hotel management decided. The Bureau, however, was able to place large numbers in surrounding towns, motor courts and private homes, while 246 nights' lodgings were provided free in the Metal Show Dorm in the Public Auditorium. There is one bright thing to look forward to—the Chicago hotels have allocated 6600 rooms for the '54 Metal Show!

Young Engineers' Day on Friday, Oct. 23, exceeded all expectations. Two special trains and countless buses brought 2264 faculty and student engineers from 11 engineering schools to Cleveland. Letters since received vouch for the success of the idea.

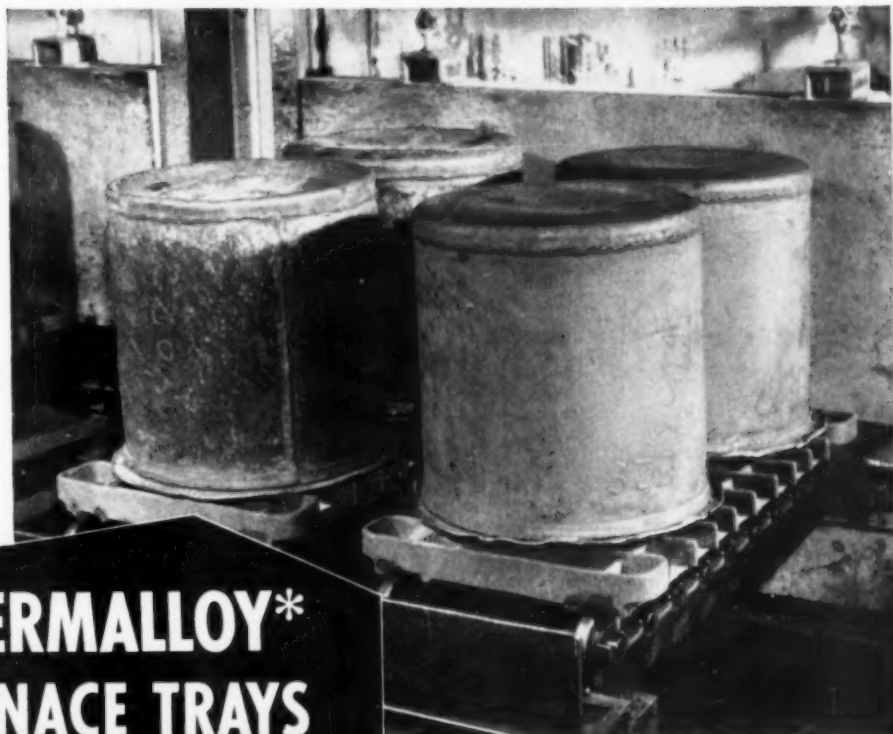
Installation of the Exposition had smooth sailing—no labor difficulties. . . . Advance Registration approximated 12,000. . . . The 15-minute coffee period, "another A.S.M. service", was a great success. . . . Free bus transportation was provided from parking grounds and leading hotels to the Exposition. . . . The slogan used on radio announcements "See the Show from one to five" produced more attendance in the afternoon than in the evening. . . . Publicity was the greatest ever given an industrial show in Cleveland . . . hundreds of newspaper inches . . . six TV periods . . . five radio interviews . . . two international TV hook-ups. . . . More technical manpower served in the booths than ever before. . . . The decor received loads of favorable comment. . . . Expressions used were . . . harmonious ensemble . . . glamorous . . . finished . . . beautiful. . . . But most of them said "Fabulous Metal Show" . . . Credit goes to the exhibitors who prepared such wonderful exhibits and who did such a fine job in presenting their products and services.

So let us have a Merry Christmas in '53, a Happy New Year in '54, and make our plans to attend the Mid-winter meeting in Boston, March 4 and 5, and the Metal Congress in Chicago, Nov. 1 to 5.

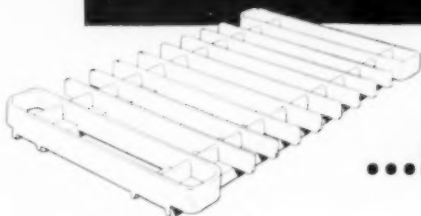
Cordially yours,

Bill

W. H. EISENMAN, *Secretary*
AMERICAN SOCIETY FOR METALS



THERMALLOY* FURNACE TRAYS



...in service over 10,000 hours!

A large automotive parts manufacturer "pack-carburizes" drive pinions in pots conveyed two on a tray through a gas-fired furnace where temperatures range up to 1700°F. Previous designs of the furnace tray cracked, warped and scaled quickly, with average service life limited between 100 and 600 hours.

This manufacturer asked Electro-Alloys engineers how service life of these trays could be extended. Electro-Alloys designed a new furnace tray... cast it in a grade of heat-resistant Thermalloy best suited for long carburizing service. Two years ago, these Thermalloy trays were installed. Today, with over 10,000 service hours each, they are still in use.

Thermalloy is not one alloy but a group of

alloys—each developed to meet specific high-temperature operating conditions. Electro-Alloys produces many types of high heat-resistant Thermalloy castings such as muffles, retorts, trays, fixtures, baskets, rollers. In many cases too, Electro-Alloys engineers can help you redesign your heat-treating parts in Thermalloy to give more operating hours per dollar. Call your nearest Electro-Alloys representative for full information or write Electro-Alloys Division, 4002 Taylor Street, Elyria, Ohio.

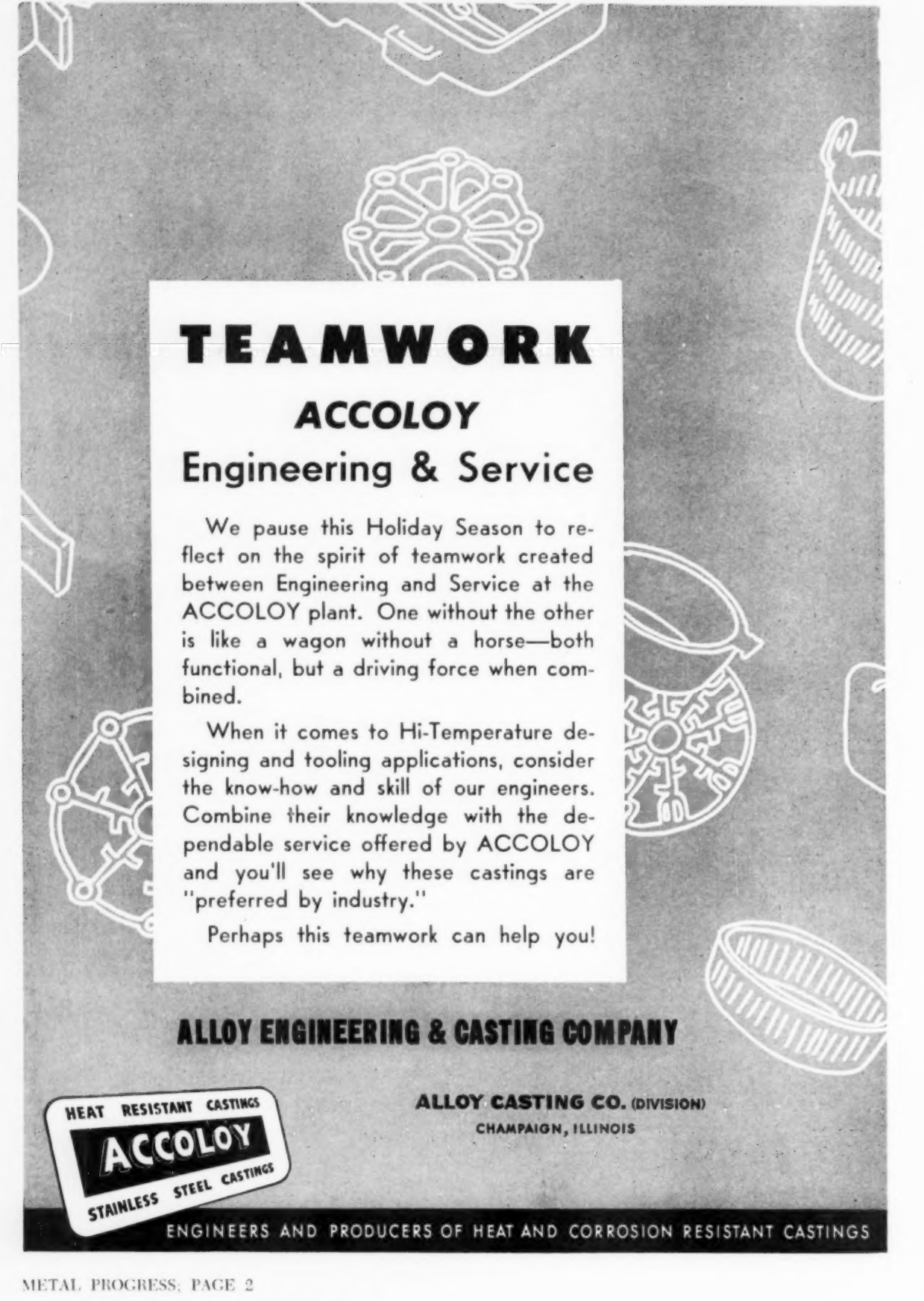
Write for new Thermalloy Tray and Fixture Bulletin T-226.



*Reg. U. S. Pat. Off.



ELECTRO-ALLOYS DIVISION
ELYRIA, OHIO



TEAMWORK

ACCOLOY

Engineering & Service

We pause this Holiday Season to reflect on the spirit of teamwork created between Engineering and Service at the ACCOLOY plant. One without the other is like a wagon without a horse—both functional, but a driving force when combined.

When it comes to Hi-Temperature designing and tooling applications, consider the know-how and skill of our engineers. Combine their knowledge with the dependable service offered by ACCOLOY and you'll see why these castings are "preferred by industry."

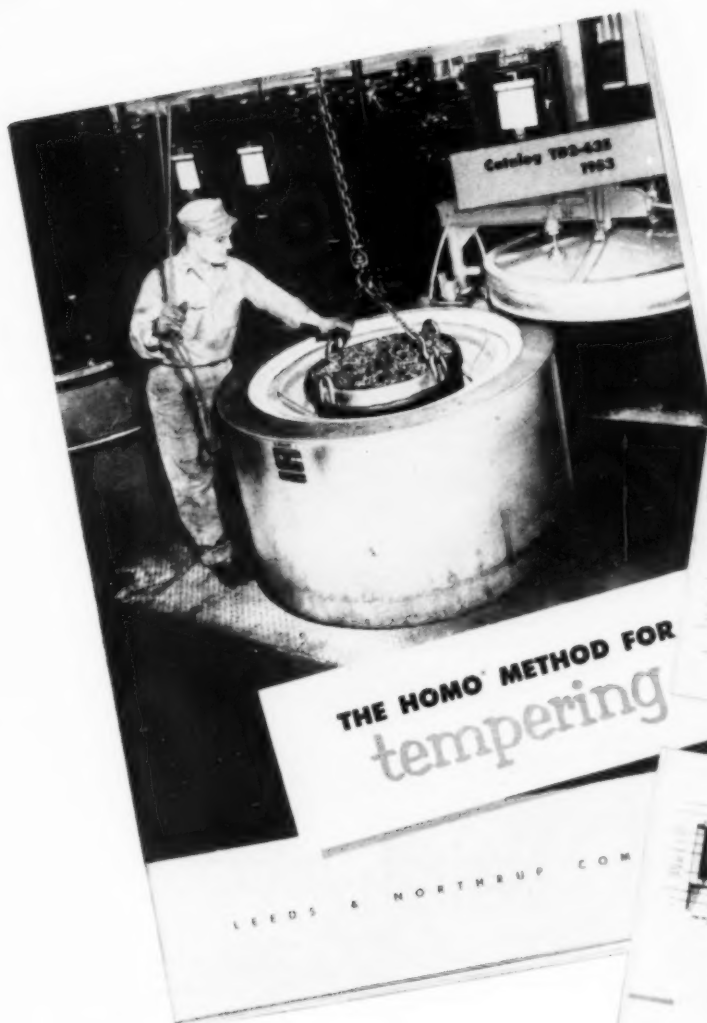
Perhaps this teamwork can help you!

ALLOY ENGINEERING & CASTING COMPANY



ALLOY CASTING CO. (DIVISION)
CHAMPAIGN, ILLINOIS

ENGINEERS AND PRODUCERS OF HEAT AND CORROSION RESISTANT CASTINGS



In this new publication you'll find photos and descriptions of typical installations, cut-away views of the furnaces, description of the control instruments, and complete specifications for various sizes of furnaces, work baskets and trays.



Brand New Tempering Ideas!

As you're reading this ad our entirely new 20-page catalog will be just off press. It tells graphically of some of the remarkable operating results being obtained in hundreds of plants by users of Homo furnaces.

Today, Homo furnaces are being used under practically every kind of operating condition . . . to meet practically every kind of specification . . . on practically every type of work . . . steel, aluminum or glass. There's a wealth of first-hand data available to you.

If your plant does tempering, at any stage of production, we believe you'll be interested in this

up-to-date information about the highly versatile Homo method . . . the five kinds of Homo furnaces and the jobs they're built to do.

We'll send your copy as soon as you request it. Just write our nearest office or 4927 Stenton Ave., Philadelphia 44, Pa. and ask for Catalog TD2-625(1).

LEEDS
instruments

NORTHRUP
automatic controls • furnaces

LEADS TD2-625(1)

Metal Progress is copyrighted, 1953, by American Society for Metals and is published at 404 N. Wesley Ave., Mt. Morris, Ill. Issued monthly.

subscriptions \$7.50 a year. Entered as second-class matter Oct. 21, 1953, at the post office at Mount Morris, Illinois, under the Act of March 3, 1879.

ONLY a few years ago, the science of sensitive, accurate measurement was limited to laboratories. But today, this science is practiced every day in thousands of industrial plants by factory men . . . who don't have to be instrument experts.

Production men wanted to put this science to work, for they had long known that many processes would function at greater efficiency if temperature, pressure and other variables could be more accurately maintained. Although these potential benefits could be proved in the laboratory or in pilot plants, they could seldom be exploited fully in actual production.

Milestone in measurement

One of the main reasons was that existing industrial methods of measurement were not sufficiently accurate, sensitive or fast. Instruments with delicate mechanical balancing systems suffer inherent limitations . . . always require a compromise between sensitivity and ruggedness . . . and can provide only periodic measurements.

Then, in 1940, the advent of *ElectroniK* instruments swept away these limitations. By adopting an entirely new approach—electronic continuous balancing—these instruments revolutionized the concepts of industrial measurement. They placed laboratory accuracy and sensitivity at the disposal of the production man . . . with all the simplicity and ruggedness demanded by indus-

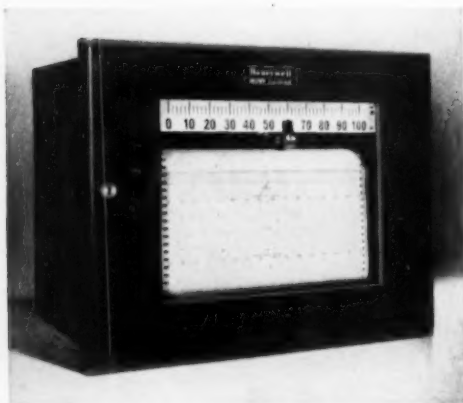
trial service . . . plus speed of response never before economically practical.

Proved by years of performance

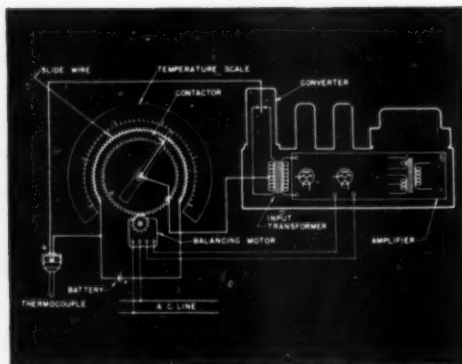
In the past thirteen years, thousands of plants have discovered almost endless applications where the superior performance of these instruments helps to improve operations. The more they learn about *ElectroniK* instruments, the more they call on them for increasingly complex tasks of measurement and automatic control.

Since 1940, the *ElectroniK* family has grown to encompass a host of new indicating, recording and controlling models . . . capable of measuring scores of different process variables . . . equipped with the most advanced types of automatic control. In anticipation of the needs of the future, Honeywell's intensive development program is bringing to readiness even more advanced equipment for tomorrow's process control problems.

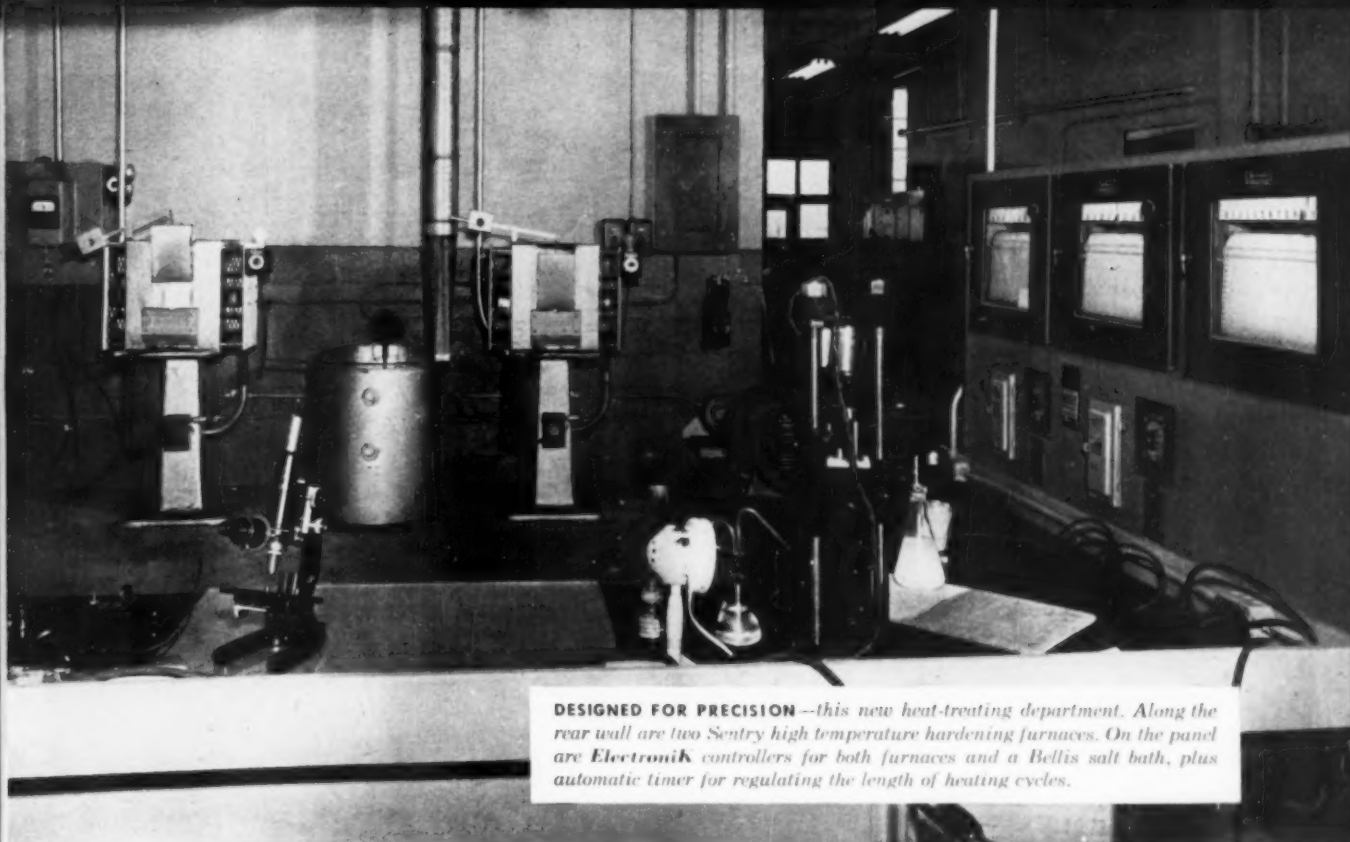
High quality taps in *ElectroniK*-



A FAMILIAR SIGHT to thousands of production men, scientists and engineers is this strip-chart *ElectroniK* Recorder, one of a complete family of indicating, recording and controlling instruments.



POWER PLANT of *ElectroniK* instruments amplifies a millionfold the minute electrical signals from thermocouples and other sensing elements.



DESIGNED FOR PRECISION—this new heat-treating department. Along the rear wall are two Sentry high temperature hardening furnaces. On the panel are *ElectroniK* controllers for both furnaces and a Bellis salt bath, plus automatic timer for regulating the length of heating cycles.

get precise hardening *controlled furnaces*

HIGH precision heat-treatment is an essential part of the fine workmanship that goes into ground-thread taps made at the North Attleboro, Mass. plant of the Charles L. Jarvis Co. These taps are made of high speed steel, hardened at precisely controlled temperatures.

The completely new heat-treating department is designed to provide the accurate quality control that the Jarvis Company demands. Hardening is performed in electrically heated furnaces made by the Sentry Co. As many as 76 taps at a time are loaded into each furnace, and heated to the hardening point in the neighborhood of 2300°F. An *ElectroniK* strip chart potentiometer, with on-off control, holds the furnace accurately to one quarter of one per cent of the instrument range.

After hardening, taps are oil-quenched, then tempered in a Bellis electrode salt bath. This bath is also controlled by an *ElectroniK* instrument which maintains temperature constant at 1050°F. The overall result of accurate heat-treating is consistently precise control over hardness . . . a prime consideration for producing fine tools.

Your own heat-treating job, too, can profit by the accuracy and dependability of *ElectroniK* control. Your local Honeywell sales engineer will be glad to discuss your applications . . . and he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO.,
Industrial Division, 4503 Wayne Ave., Philadelphia 44, Pa.

● REFERENCE DATA: Write for Catalog 1530, "ElectroniK Controllers."



MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS

First in Controls

Which of these BASIC MATERIALS will solve *your* processing problems?

Norton **R**electric furnace products are
engineered and prescribed
to meet many manufacturing needs

Backed by over 50 years of experience in electrochemical refining, Norton brings you basic materials whose purity and properties are carefully controlled and consistently duplicated.

These Norton electric furnace products differ greatly in composition and characteristics. They are the source of the many Norton *engineered prescriptions* which have proved of immense practical value in widely varying processes.

Moreover, each of them has possibilities for use which are still undiscovered. It will pay you, therefore, to read the following descriptions very carefully. Even this partial list may contain the exact combinations of properties you need.

ALUMINUM OXIDE (ALUNDUM®)

Norton is the world's largest producer of this basic material — fused alumina. *Characteristics:* high melting point, about 3700°F; specific gravity, 3.95; good chemical stability, neutral to most chemical reagents; extreme hardness of 2000 Knoop, with great toughness; reasonably high thermal conductivity, 2½ times that of fire clay; high dielectric strength. *Uses:* heavy refractory furnace shapes; pure oxide and sintered refractories; radio tube insulation; porous media for filtration and diffusion; catalyst carriers and fluid catalysts; heat exchange pebbles; wear-resistant parts; laboratory ware.

SILICON CARBIDE (CRYSTOLON®)

Silicon carbide is produced by Norton in large tonnages. *Characteristics:* high melting point, disassociates at about 4175°F; specific gravity, 3.20; extreme hardness of 2500 Knoop, with excellent abrasion and erosion resistance; high thermal conductivity, 7 to 10 times that of fire clay; excellent resistance to thermal shock; maintains great strength to very high temperatures (PCE, 3350°F — cone 37 to 40); unique electrical qualities; relatively low thermal expansion; no inversion on heating; chemically acidic, with good stability. *Uses:* special refractories for boiler furnaces, ceramic kiln furniture, heat treating, hearth plates, high thermal conductivity muffles and retorts; electrical heating elements; lightning arrestors; metallurgical additions; also available in a Norton-patented process for coating graphite — in rocket nozzles and reaction motor parts, etc. — for increased resistance to erosion by high velocity gases.

MAGNESIUM OXIDE (MAGNORITE®)

Fused magnesia of highest purity. *Characteristics:* extremely high melting point, about 5,000°F; specific gravity, 3.58; electrical resistivity, 10⁸ ohm cm at 1000°C; chemically basic. *Uses:* linings for metal melting furnaces; high temperature electrical insulation; refractories for handling corrosive caustic materials.

FUSED STABILIZED ZIRCONIA

Norton was the first to develop fused zirconia for practical commercial use. *Characteristics:* high melting point; thermal conductivity in British Units at 2000°F is 6.2 for dense shapes, 4.7 for insulating shapes, 2.8 for insulating grain; high resistance to abrasion and thermal shock; not wet by most molten metals; changes from a fairly good electrical insulator at low temperature to a conductor at 1000°C. *Uses:* refractories for extremely high temperatures; setter plates for titanates; furnace linings for high temperature gaseous chemical reactions; zirconium chemicals; metal melting furnace linings; catalyst carriers; heat exchange pebbles; reaction engine parts including jet and rocket liners.

BORON CARBIDE (NORBIDE®)

The hardest man-made material, an exclusive Norton development of boron carbide. *Characteristics:* high melting point, 4440°F; specific gravity, 2.50; compressive strength, 414,000 psi; bending strength, 44,000 psi; self-bonding, unaffected by all acid and alkali solutions. *Uses:* abrasive for economical replacement of diamond dust in lapping; high purity powder of micron sizings for use as refractory and in "cermet" combinations; neutron absorption in nuclear reactors or particle accelerators; pressure-blast nozzles; wearproof bushings, slides, etc.



In these Higgins type arc furnaces tremendous amounts of electrical energy are utilized by Norton in electrochemically refining crude minerals into basic R refractory materials.

BORON NITRIDE

Refined by Norton to over 98% purity. *Characteristics:* melts or disassociates at 5400°F; a nonconductor of electricity; weighs only 7 lbs. per cu. ft.; is not oxidized in air at 1200°F. *Uses:* anti-sticking agent for use with molten glass or metal; heat-resistant lubricant; thermal insulator in vacuum or atmosphere furnaces; experimental refractory or crucible material; experimental electrical insulator.

MANY OTHER MATERIALS

Among the high-melting, useful materials made available by Norton are Special Fused Oxides, Refractory Carbides, Refractory Borides, Mixed Borides, Elemental Boron. Research, development and field testing are being conducted on Experimental Borides, Carbides, Nitrides and Silicides. Some of these are in regular industrial use and new uses are being found for others.

AVAILABLE IN MANY STANDARD OR SPECIAL FORMS

Besides supplying these materials in their crude form, more or less as they come from the furnace, Norton has extensive facilities for processing and fabricating — and is ready to work with you in engineering any of these materials to your particular requirements.

GET THIS BASIC MATERIALS BOOKLET

This new Norton Publication, "Basic Materials," contains 22 pages of detailed information, including actual and suggested uses. For your copy, write to NORTON COMPANY, 331 New Bond St., Worcester 6, Mass. Canadian Representative: A. P. Green Fire Brick Co., Ltd., Toronto, Ontario.



NORTON
R REFRACTORIES

Making better products... to make other products better

*Trade-Marks Reg. U. S. Pat. Off. and Foreign Countries



IMPACT EXTRUSIONS ARE NOW POSSIBLE IN MAGNESIUM

Savings in tooling and materials handling plus single-step operation assures substantial cost reductions.



The newest technological advancement in the fabrication of *magnesium* is impact extrusion. As a result, it is now possible for more industries than ever before to take full advantage not only of the remarkable qualities of the world's lightest structural metal, but also of the many benefits of impact extrusions.

Here, for example, are just a few of the advantages magnesium impact extrusions provide: (1) Larger parts and more intricate shapes can be impact extruded with less pressure than required for other metals. (2) Impact extrusion die life is extremely good. Many thousands of parts have been made on a single set of dies. (3) Parts can be made in a one-step operation, instead of a sequence of steps required by other methods. (4) More impact extru-

sions can be made from a pound of magnesium than from a pound of any other metal.

In addition to the advantages of the process, magnesium contributes its own properties which make it exceptionally useful wherever strength and light weight are design factors. It's one-third lighter than aluminum. It's strong and rigid. It has excellent resistance to many organic chemicals and oils. It possesses good electrical conductivity.

Why not consider magnesium impact extrusions to help reduce your costs . . . to help boost your production . . . to help solve your problems. For more data pertaining to your operations, write to us directly. THE DOW CHEMICAL COMPANY, Magnesium Department, Midland, Michigan.

you can depend on DOW MAGNESIUM



EASY-FLO AND SIL-FOS

LOW-TEMPERATURE SILVER ALLOY BRAZING

...the Modern Designer's key to fast, low-cost metal joining



TYPIFYING the fast, low-cost EASY-FLO and SIL-FOS production formula is this brass sleeve and stamped steel case assembly. Parts are positioned in jigs with the alloy preplaced — then assemblies are induction brazed 6 at a time in 31 seconds. Unskilled labor does it all.



NOT LIMITED TO NEW DESIGNS

Numerous parts joined by other methods have been redesigned for EASY-FLO and SIL-FOS brazing's faster production and lower costs. Likewise, many cast and forged parts have been changed to EASY-FLO and SIL-FOS brazed assemblies of stampings and simple screw machine pieces.

• This is the process that opens the door to amazing speed, reliability and economy in the production of metal assemblies.

It's the process that...

- (1) assures exceptional joint strength plus the ductility to withstand any stresses and strains the joined metals will take.
- (2) naturally and consistently makes joints that are liquid and gas-tight—also high in electrical conductivity, heat transfer and resistance to corrosion.
- (3) joins thin metals without danger from overheating.
- (4) makes possible fast, fool-proof metal joining with unskilled labor.
- (5) brings metal joining costs down to surprisingly low figures.

It's the process that deserves first consideration in the *design stage* because that's where your product's quality and cost of production are determined.



LET OUR FIELD ENGINEER HELP

He will place at your service the maximum technical knowledge about silver alloy brazing and practical experience in its application available today. He'll call entirely without obligation. Just write and say when.

FOR THE FACTS IN PRINT

Bulletin 20 gives the complete EASY-FLO and SIL-FOS story plus a lot of valuable information about joint design and fast production brazing methods. Write for a copy.

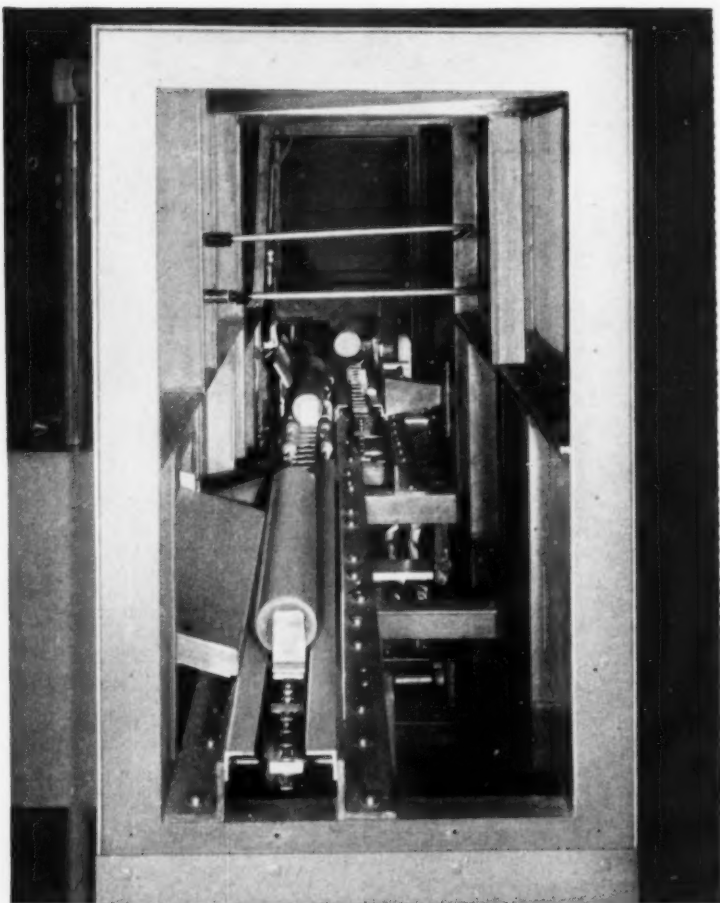
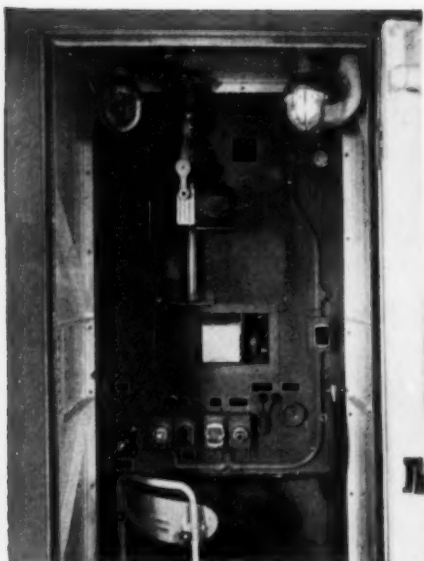


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Inspection Problem Solved with

Westinghouse Fluoroscopy

Advisory Service Available

Westinghouse now offers industrial fluoroscopy as well as conventional X-ray techniques. These methods have solved difficult problems; Westinghouse will be happy to consult with you on any special inspection problems.

At the Hercules Powder Plant, in DeSoto, Kansas, the Westinghouse Fluoroscopic unit (above) has been designed for internal inspection of explosive powder grains for airborne rockets. At left is the operator's booth, at right the conveyor. This X-ray unit permits a continuous stream of large, cylindrical grains to be thoroughly inspected by a single operator. Design provides for easy

location and identification of defect areas and for the automatic rechanneling of faulty grains. Results: quick, positive, low-cost inspection without costly, cumbersome film requirements.

If you face a tough inspection problem it will pay you to investigate Westinghouse Fluoroscopic equipment. Westinghouse is equipped to apply the best technical assistance to the solution of your particular inspection problems. Call your Westinghouse representative or write to Westinghouse Electric Corporation, Dept. O-68, 2519 Wilkens Avenue, Baltimore 3, Maryland.

X-RAY DIVISION • WESTINGHOUSE ELECTRIC CORPORATION • BALTIMORE 3, MARYLAND

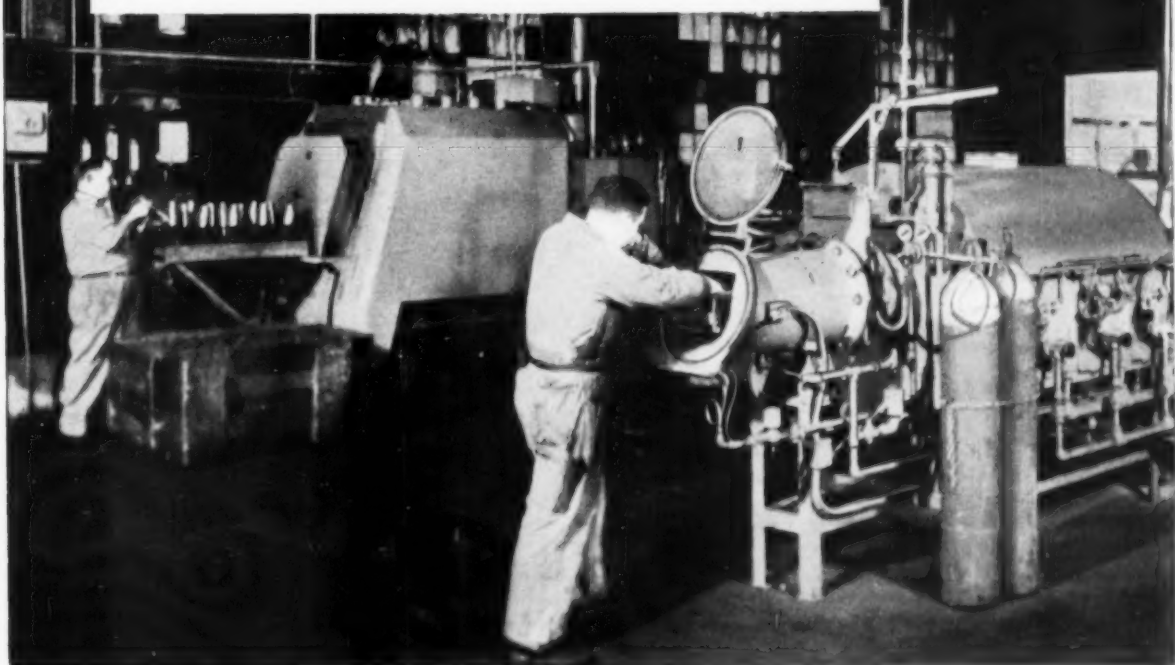
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ACCESSORIES

YOU CAN BE SURE...IF IT'S

Westinghouse

J-08268

CARBONITRIDING AND ARMOUR AMMONIA INCREASE PRODUCTION AT PEARSON COMPANY



New processes prove more efficient, safer for metal treating

Those carbonitriding and brazing furnaces above mean greater production and safety at the Pearson Industrial Steel Treating Company in Chicago. And Pearson specifies Armour's pure, dry ammonia and dependable service for their carbonitriding.

All through the metal treating field, plants are using every improved process they can to provide their clients with better work. Since many of these new processes require ammonia, more and more companies like Pearson are calling on Armour ammonia and service for best results.

Carbonitriding has reduced costs and increased safety in many plants. And Armour men were there in many cases to give advice and help on installations. Those men in Armour's Technical Service Department are equipped and ready to help you in your installation.

Since 1947 Armour has sponsored a fellowship at the Massachusetts Institute of Technology for the study of carbonitriding and other modern metal treating processes. That knowledge is basic research, and available to you.

The booklets offered at right will show you how to put this knowledge to work in your plant. Write today for free copies. If your ammonia problem is unusual or pressing, write us today giving full details of your requirements.

Clip and mail this today!

- ☐ "Applications of Dissociated Ammonia"
☐ "Ammonia Installations for Metal Treating"
☐ "The Nitriding Process" ☐ "Carbonitriding"

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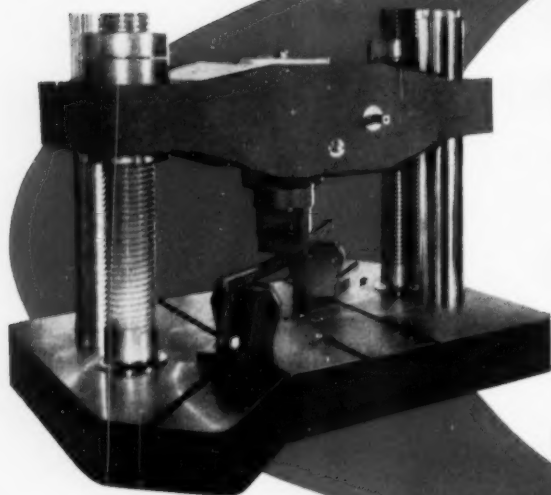


You can depend on Armour's ammonia and service

ARMOUR

Ammonia Division

Armour and Company • 1355 West 31st Street • Chicago 9, Ill.



Typical set-up for testing bending stress in bar stock.

How Physical Testing HELPS METALS ENGINEERS

You won't waste money processing substandard materials if you use physical testing at several stages of production.

Incoming Materials — You can quickly and easily check the quality and uniformity of incoming raw material and parts. Materials not up to your standards can be rejected before flaws show up in machining or assembly.

Sub-Assemblies — By regularly testing sub-assemblies, you can check the quality of welds, riveted joints or other operations. Faulty operations can be remedied before a large number of substandard parts are produced.

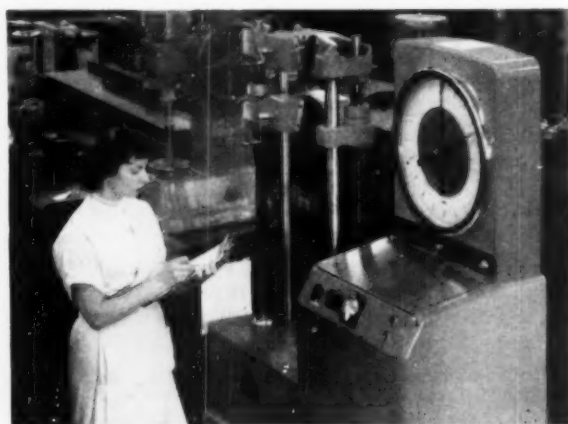
Finished Products — Sample testing of finished products will assure that your products meet your company standards. Customer complaints will be reduced and returned products minimized.

You can test practically anything with a Riehle Universal Testing Machine. Because it has five standard

scale ranges, the Riehle Pendomatic Universal Testing Machine is the equivalent of five testing machines in one. You merely turn the selector knob to the proper range and conduct your test. Accessories and special tools are available for special tests.

Riehle Universal Testing Machines are built with hydraulic or screw power loading units. Each type is available in a variety of sizes with capacities up through 400,000 lbs.

Write for illustrated catalog containing specifications and accessories to Dept. MP-1253.



Riehle Universal Testing Machine checking tensile strength of a finished part.

RIEHLE TESTING MACHINES

Division of American Machine and Metals, Inc.
EAST MOLINE, ILLINOIS

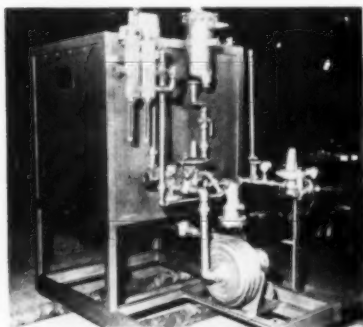
"ONE TEST IS WORTH A THOUSAND EXPERT OPINIONS"

engineering digest

OF NEW PRODUCTS

Atmosphere Generator

Ferguson Equipment Corp. has announced a new endothermic type of protective atmosphere generator for protecting metals during heat treatment. This generator features a rectangular alloy retort in the smaller sizes and centrifugally cast alloy re-



torts in the larger sizes. Radiant tube type elements can be changed during operation. Flow meters and regulators, safety equipment and automatic temperature controls, automatic atmosphere control apparatus and gas enrichment are available.

For further information circle No. 1672 on literature request card on p. 32-B.

Ferro-Beryllium

A master alloy of 5% beryllium in iron, announced by the Beryllium Corp., is designed for making beryllium additions to stainless steels. The alloy has proved successful in the newly developed hardenable 18-8 stainless steel known as V2B. Previous attempts to add beryllium to 18-8 stainless proved impractical when high hardness advantages produced were negated by extreme brittleness and poor machinability. V2B has brought beryllium back into the picture.

For further information circle No. 1673 on literature request card on p. 32-B.

Cutting Oil Base

Dasco, a new soluble base oil, has been especially formulated for metal cutting and grinding by D. A. Stuart Oil Co. It can be used in leaner mixtures than ordinarily recommended for soluble oils. Mixtures usually start at 40 to 1 for milling, drilling, turning, boring, sawing and reaming.

Grinding mixtures leaner than 100 to 1 have given good results.

For further information circle No. 1674 on literature request card on p. 32-B.

Metal Remelter

The Nolan Corp. has announced a self-contained unit for remelting of soft metals such as babbitt, solder, tin, zinc, lead and lead alloys. This furnace features compact design, automatic loading, enclosed melting pot, optional means of pouring molten metal and water cooled molds. Pot capacities are available from 600 to 10,000 lb. with optional oil, gas or electrical firing for selectively timed preheat and automatically controlled temperatures up



to 850° F. for standard models, and 1000° F. for optional designs.

For further information circle No. 1675 on literature request card on p. 32-B.

New Abrasive Belt

Minnesota Mining and Manufacturing Co., has announced a new type heavy-coated abrasive belt, combining the polishing characteristics of hand-coated glue and grain set-up wheels and belts. Preliminary field tests have shown that use of the new belt increases production with additional economies in polishing costs, the firm stated. The heavy mineral build-up of the belt opens up under work pres-

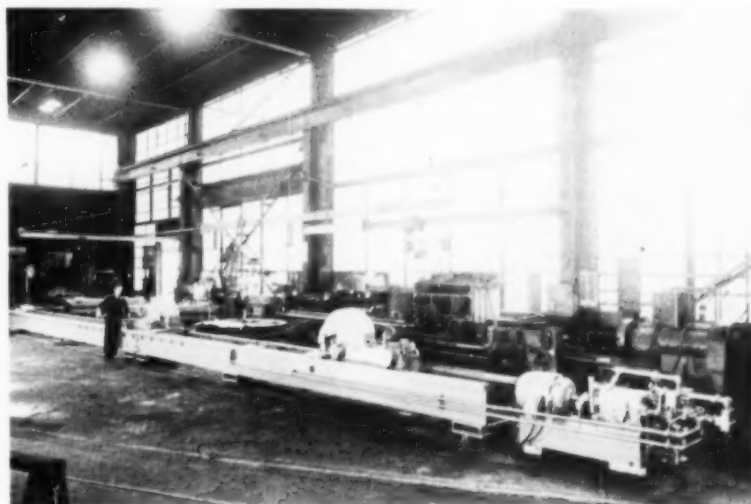


Stretcher Leveler

Details on its new stretcher leveler have been issued by the Medart Co. This new machine is completely automatic in operation. The piece to be leveled is placed between the grip jaws by the operator and pushbutton control initiates the clamping of the grip jaws. The machine automatically travels at a high rate of take-up speed and shifts down automatically to a low-speed stretching cycle, and as

soon as the preset percentage of stretch is reached, the cycle is automatically stopped, the stretching cylinder unloaded and the jaws opened. The machine can be set from its extreme length of 45 ft. down to 10 ft. in 30 sec. The stretching cylinder is capable of producing a 50-ton stretch continuously, and has a selection of three speeds.

For further information circle No. 1676 on literature request card on p. 32-B.

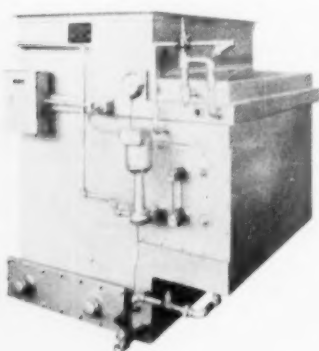


sure, presenting fresh abrasive grain particles to the work piece. The new belt is available in grit 60 and grit 150 aluminum oxide mineral in all standard widths and lengths.

For further information circle No. 1677 on literature request card on p. 32-B.

Vapor Degreaser

Significant improvement of vapor degreasing equipment is claimed by Metalwash Machinery Corp. Its features include: obstruction free tank walls, recessed condensing coils, recessed condensate tray, removable



pump chamber and water separator of solid stainless steel, one-end maintenance and demand-type control of water into the condensing system. The recessed multi-tiered condensing coil extends for the full length of the degreaser. Design permits conversion of a straight vapor degreaser to a vapor spray degreaser by the user. Simple installation and maintenance are claimed.

For further information circle No. 1678 on literature request card on p. 32-B.

Spot Welding Gun

The Aircospot gun, a new light weight spot welding gun by Air Reduction, uses a 3/32-in. nonconsumable thoriated tungsten electrode and an inert-gas shield. It makes instantaneous welds on stainless, mild



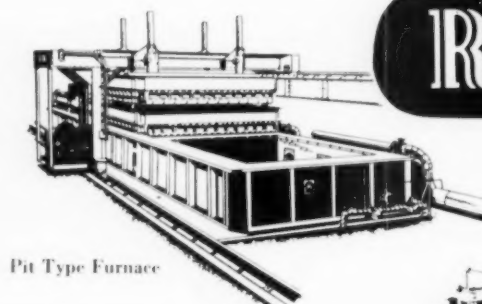
and alloy steels, without the aid of jigs or fixtures. The unit consists of a hand gun, control panel and all necessary hose and cable assemblies. In order to use this equipment, a standard d-c. power source, either

motor-generator set or rectifier type, is required. The gun is water-cooled, and uses helium or argon, or a mixture of the two, for a shield. High frequency is not required. The gun is rated at 250 amp. and welds may be made on sheet metal up to 1/8 in. thick. In most cases, a back-up plate is unnecessary. The operator need only position the top sheet on the piece to which it is to be joined, position the gun and pull the trigger. The operation is completed in approximately one second.

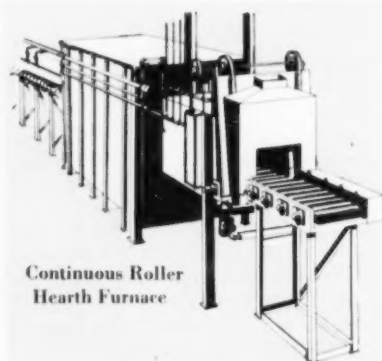
For further information circle No. 1679 on literature request card on p. 32-B.

X-Ray Film

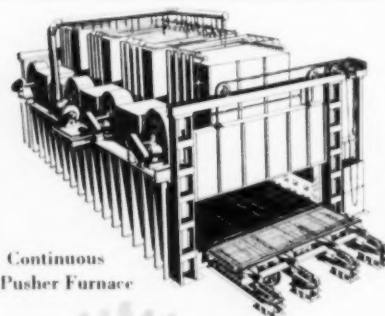
A new ultra-fine-grain industrial X-ray film has been developed by Du Pont. Known as Type 510, the film can be used at low voltages (10 to 20 peak kilovolts) to examine low-opacity materials such as aluminum and magnesium. With million-volt X-ray or betatron equipment, it may be used to examine steel up to 3 in. thick. The new film can be used to particular advantage on subjects where very minute detail is desired, since the fine-grain emulsion permits detection of tiny flaws in, for example, spot welding of aluminum sheet.



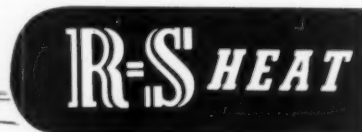
Pit Type Furnace



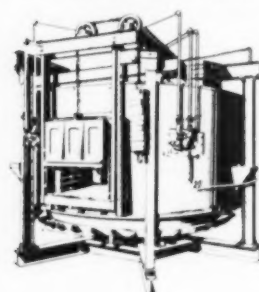
Continuous Roller Hearth Furnace



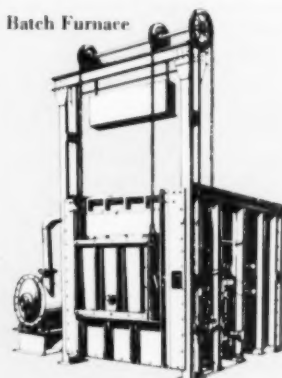
Continuous Pusher Furnace



Rotary Hearth Furnace



Batch Furnace



R-S FURNACE TYPES

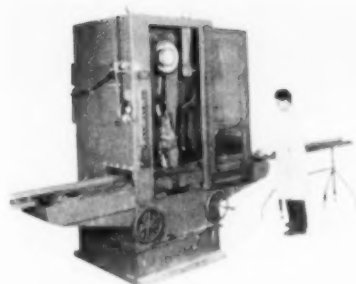
Hi-Head • Batch • Rotary Hearth • Continuous
Belt Conveyor • Continuous Chain • Continuous
Pusher • Continuous Pusher Tray • Pit •
Continuous Roller Hearth • Car Hearth

Type 510 is designed for use without calcium-tungstate intensifying screens.

For further information circle No. 1630 on literature request card on p. 32-B.

Grinding Aluminum Extrusions

Because aluminum extrusions usually come in 21-ft. lengths, the handling problem for any form of grinding has been difficult and costly. The operation can now be performed at substantial saving with the Curtis Straight-O-Matic machine in conjunction with Carborundum's abrasive



cloth belts. This setup, shown in the accompanying photograph, accomplishes the polishing of extruded

aluminum so rapidly that it has eliminated the five to six backstand operations formerly needed to meet production requirements. One pass with a 120-grit belt, at a feed speed of 10 to 15 ft. per min., has been found sufficient to remove surface imperfections or scratches from the extrusions. Surfaces obtained with 120 to 400 grit are suitable for anodizing. Oil, greases or water may be used in addition to dry grinding.

For further information circle No. 1681 on literature request card on p. 32-B.

Coolant Cooler

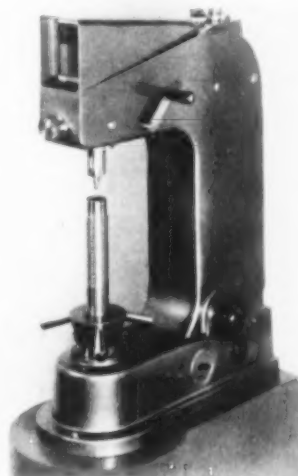
A new coolant cooler for high-production machining operations on hones, lappers, surface grinders, thread grinders and other applications requiring greater control over coolant temperature is announced by Webber Manufacturing Co., Inc. It is designed for normal installation in the coolant line between the pump and the nozzles. Coolers are available in a variety of capacities and sizes for all coolant applications.

For further information circle No. 1682 on literature request card on p. 32-B.



Hardness Testers

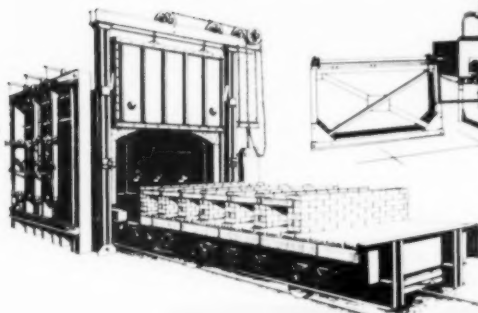
The first hand-operated metal hardness testers to provide automatic load changing and magnified optical readings have been announced by the Oplum Co., Inc. The new instruments



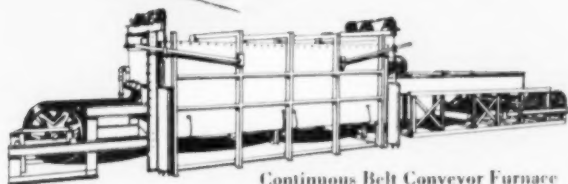
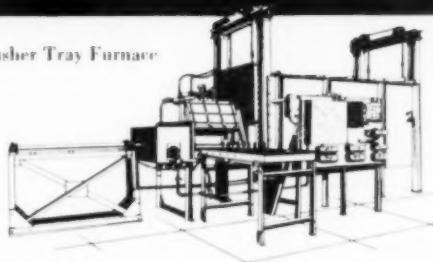
are available in both superficial and standard ranges. Automatic changing of loads is done quickly and simply by turning a dial which immediately switches the loads in the interior of the instrument. With this new and exclusive feature, the tester, in re-

TREATING FURNACES

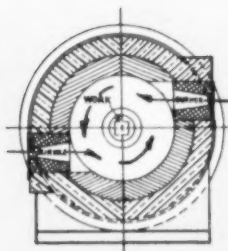
Continuous Pusher Tray Furnace



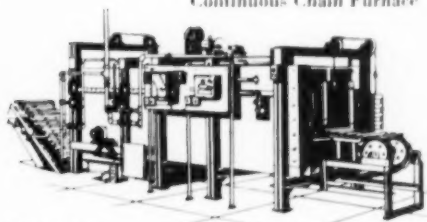
Car Hearth Furnace



Continuous Belt Conveyor Furnace



Continuous Chain Furnace



Hi-Head Furnace

R-S FURNACE CORP.

4555 GERMANTOWN AVENUE
PHILADELPHIA 44, PENNSYLVANIA

A SUBSIDIARY OF
HARDINGE COMPANY, INC.



cent factory tests, was able to equal and better testing times of a completely automatic instrument. The speed of load application is regulated by a built-in oil damper with an external control. The testers are able to accept samples up to 7½ in. thick.

For further information circle No. 1683 on literature request card on p. 32-B.

Resin Finishes

Two new products have been announced by Parker Rust Proof Co.—Parcolac 101 Black and Parcolac 102 Aluminum, pigmented phenolic resin finishes. The 101 Black produces a

deep black color; 102 Aluminum creates an even, light gray finish which looks like a coating of aluminum. Production pieces have withstood 100 hr. in salt spray.

For further information circle No. 1684 on literature request card on p. 32-B.

Largest Radiograph

A 40 by 120-in. radiograph, the largest yet produced on a single piece of film, was displayed at the National Metal Congress in Cleveland by Allis-Chalmers Mfg. Co. The giant magnification of two Winchester rifles was accomplished with an Allis-Chalmers

22-mev betatron by using a "magna scanning" technique. Magnification of the rifles was accomplished by direct geometrical enlargement with the film placed 8 ft. from the specimen. The target-to-specimen distance was 4 ft. and the target-to-film distance 12 ft. This resulted in a magnification factor of three. The scanning arc traversed was about 40° which resulted

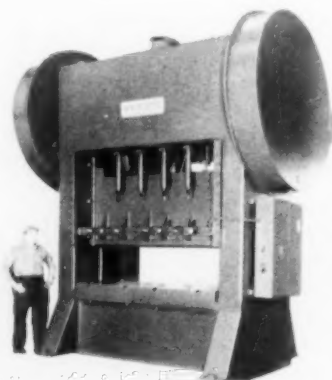


in the center of the X-ray beam being swept across the full length of the specimen. This technique when employed in industrial radiography has been successful in revealing details of flaws down to 0.001 in.

For further information circle No. 1685 on literature request card on p. 32-B.

Heavy Press

The Cleveland Crane & Engineering Co. announce their entry into the heavy press field with the introduction of a completely new line of presses of 160 tons capacity and up. The new "Wickliffe" presses are intended for uses such as forming,

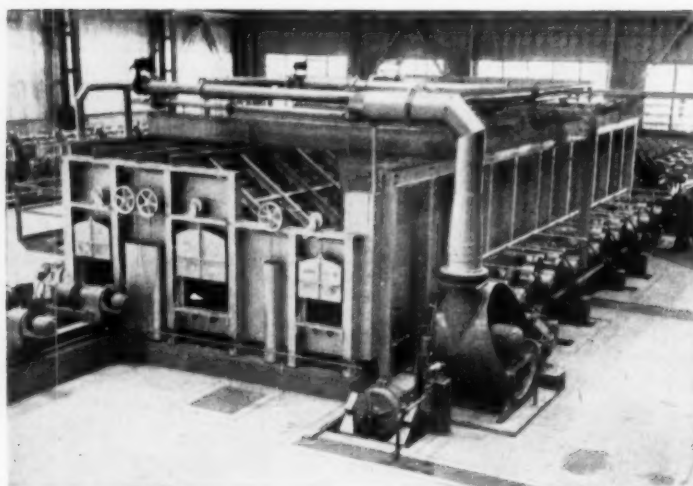


blanking, piercing, trimming, light embossing and drawing. The equipment shown in the illustration is a single-action, straight-side, double-crank mechanical press, rated at 245

F & D FURNACES

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for your specific requirements



NORMALIZING FURNACE FOR SEAMLESS TUBES
• 30 TONS PER HOUR •

ALUMINUM • BRASS • STEEL • COPPER

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- Billet Heating
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- Bright Annealing
- Bright Hardening
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- Scale-Free Annealing
- Carburizing
- Drawing
- Enameling

- Forging
- Short Cycle
- Malleable Annealing
- Normalizing
- Quenching and Heat Treating Machines
- Hardening
- Continuous Conveyor
- Rotary Hearth
- Radiant Tube

Send for Free Descriptive Bulletin

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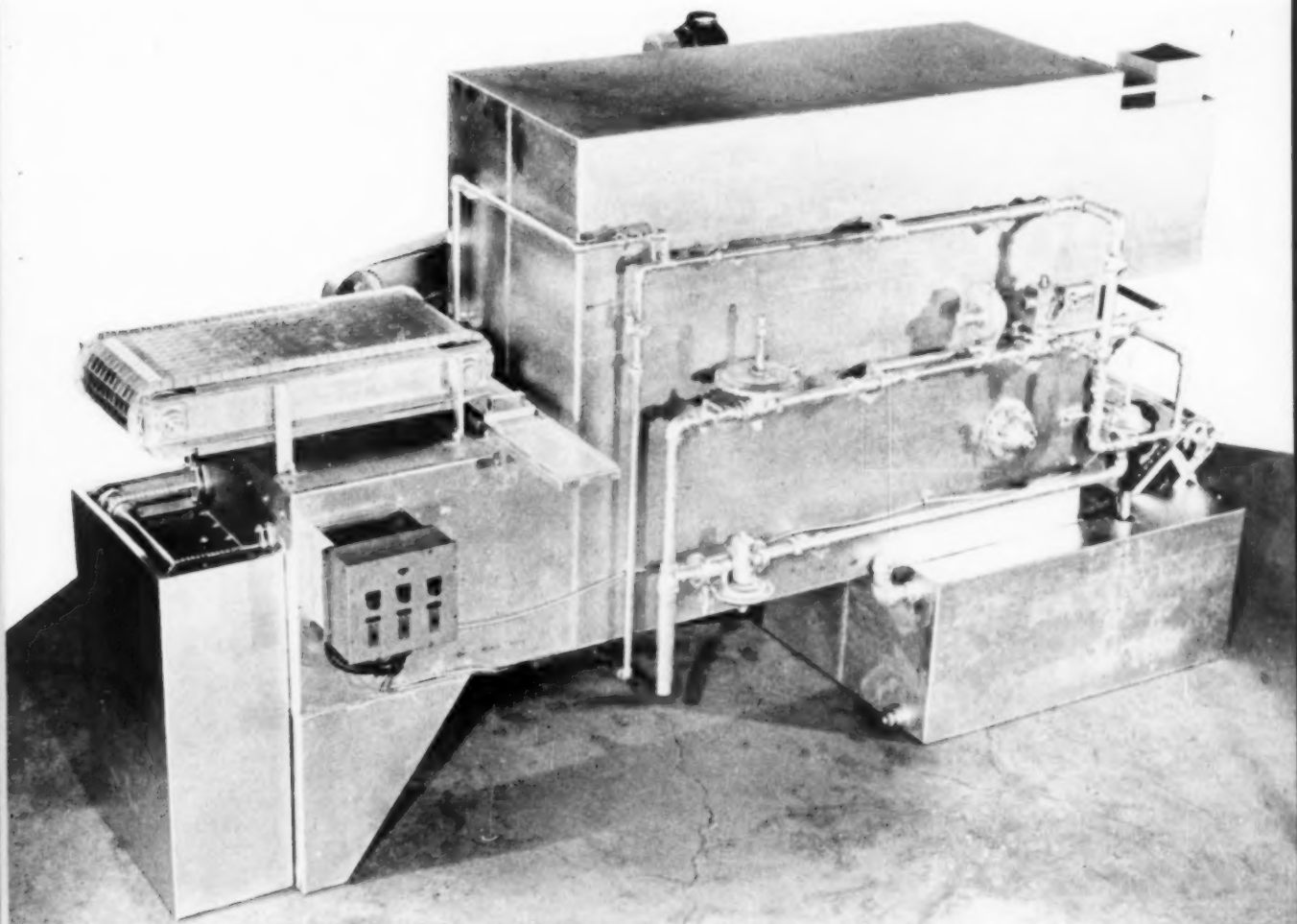
Jersey City, N. J.
Cleveland, Ohio
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FLINN & DREFFEIN Engineering Co.

27 East Monroe Street

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Value Plus (+) for the Heat Treater



CA-150 Semi-Continuous Clean Hardening Furnace... 150 Lbs. Per Hour of Small Parts

CA-150 will produce large profits on a low initial investment. CA-150 unit with a built-in generator can be installed anywhere at a very low cost. All you do is connect up the gas and water and plug in the electrical supply. Investigate the CA-150 Clean Hardening Furnace. It will solve many of your heat treating problems!

INDUSTRIAL HEATING EQUIPMENT CO.

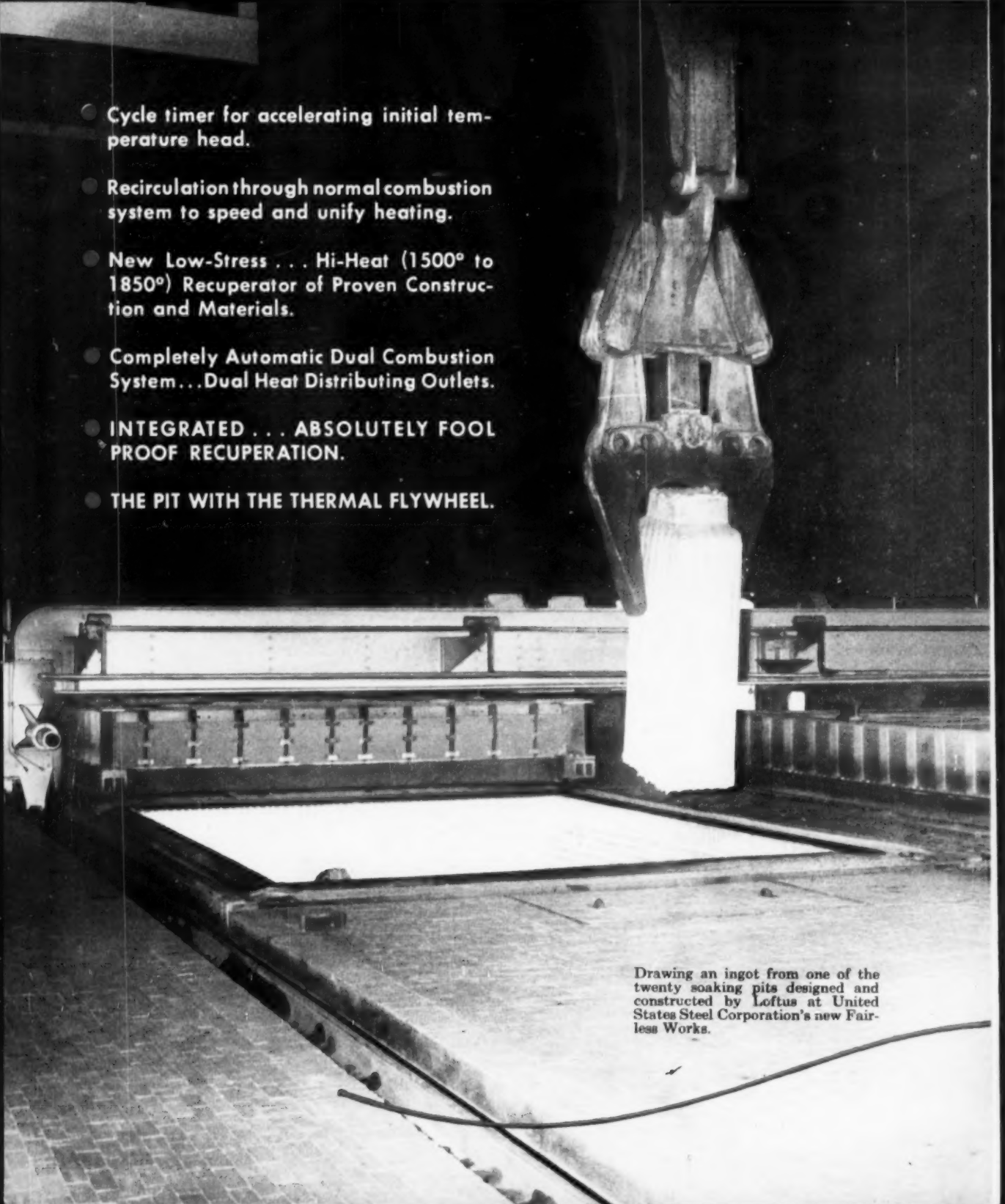
Manufacturers of Industrial Furnaces and Oil Burners Since 1917

3570 FREMONT PLACE

DETROIT, MICHIGAN

1954 DESIGN and

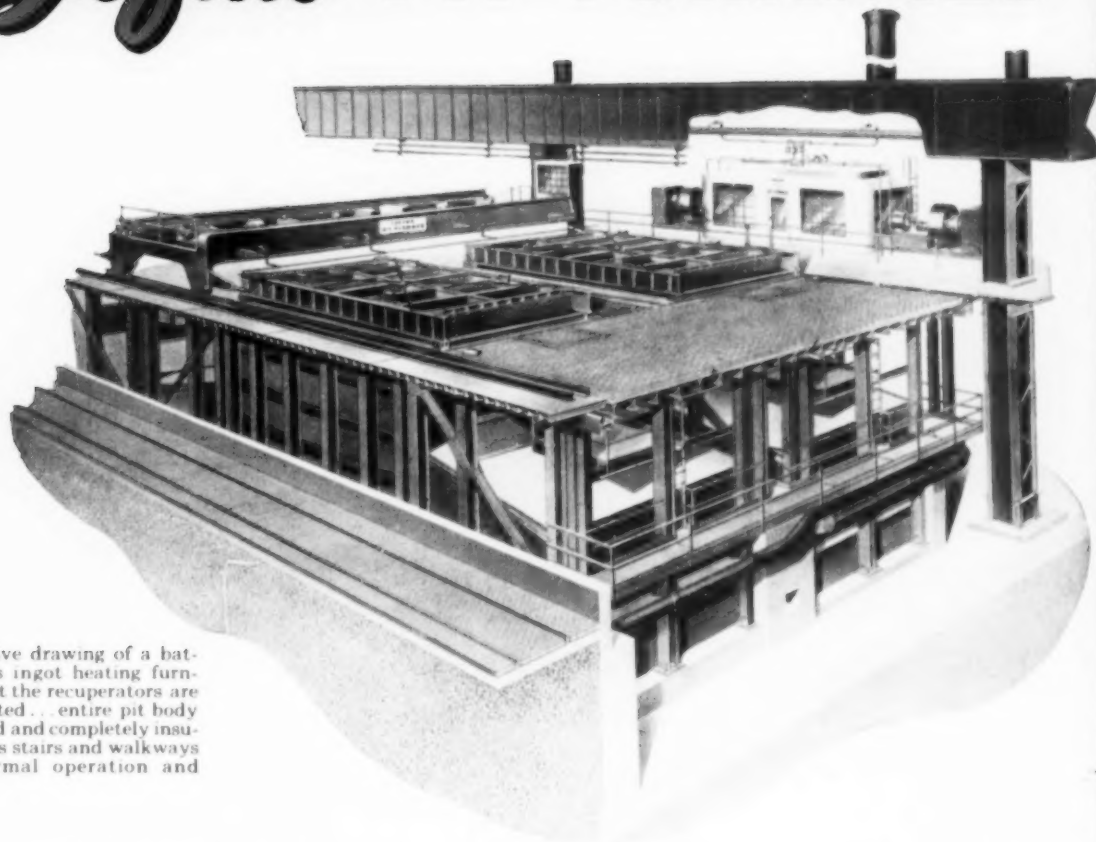
- Cycle timer for accelerating initial temperature head.
- Recirculation through normal combustion system to speed and unify heating.
- New Low-Stress . . . Hi-Heat (1500° to 1850°) Recuperator of Proven Construction and Materials.
- Completely Automatic Dual Combustion System . . . Dual Heat Distributing Outlets.
- INTEGRATED . . . ABSOLUTELY FOOL PROOF RECUPERATION.
- THE PIT WITH THE THERMAL FLYWHEEL.



Drawing an ingot from one of the twenty soaking pits designed and constructed by Loftus at United States Steel Corporation's new Fairless Works.

PERFORMANCE

with *Loftus* PIT FURNACES



True perspective drawing of a battery of Loftus ingot heating furnaces. Note that the recuperators are wholly integrated . . . entire pit body is rigidly bound and completely insulated . . . access stairs and walkways facilitate normal operation and maintenance.

The Loftus top-fired recuperative pit furnace combines all the accepted improvements in the modern ingot heating furnace PLUS new features designed to accelerate production . . . improve temperature uniformity . . . increase fuel economy . . . and reduce pit maintenance and steel conditioning costs. The improved Loftus tile recuperator reduces leakage and

provides a "Thermal Flywheel" which helps return the pit to normal operating temperature in the shortest possible time after charging.

Each Loftus Pit Furnace features "Heat Acceleration" . . . synchronized to ingot charging temperature . . . to increase production; and "Flame Tempering," to prevent overheating, and to insure uniformity. Write today.

WRITE TODAY! Actual operating data on Loftus Pit Furnaces will be made available upon request. Ask for latest literature describing in detail Loftus 2-way top-fired recuperative soaking pits.

Loftus

ENGINEERING CORPORATION
Designers and Builders of Industrial Furnaces

610 Smithfield Street, Pittsburgh 22, Pennsylvania





If you use pyrometers, you need THERMOCOUPLE EXTENSION WIRES

THERMO ELECTRIC extension wires utilize the most advanced synthetic insulations — they maintain accuracy by protecting wires from moisture, petroleum products, and most other chemicals, even after extensive use at temperatures as high as 600°F. This means longer service for wires, less replacement cost for you.



GET DETAILED DATA;
WRITE FOR BULLETIN 31-H
TODAY.

Thermo Electric Co., Inc.
FAIR LAWN NEW JERSEY

Industry, whether it be aircraft, chemicals, petroleum, plastics, metals, or any other field that requires accurate temperature measurement, profits from our experience and complete wire-making facilities. Our plant handles all phases of wire-making and thus maintains uniformly high quality. Standard wires are shipped from stock, special orders are produced promptly.

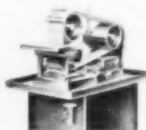


tons. Its bed is 48 x 84 in. and is equipped with air cushions.

For further information circle No. 1686 on literature request card on p. 32-B.

Carbide Tool Finisher

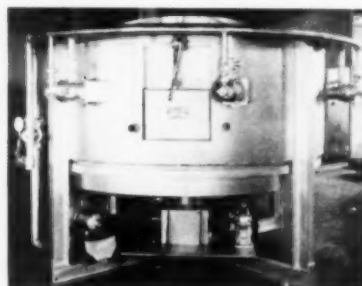
A new method and a new machine for the final finishing of carbide and high speed tools has been perfected by Hammond Machinery Builders. It features a tungsten carbide faced platen, a conventional work table, and abrasive belts in place of diamond wheels. The equipment is for final finishing after rough grinding with a silicon carbide wheel.



For further information circle No. 1687 on literature request card on p. 32-B.

Rotary Hearth Furnace

The Waltz rotary hearth furnace shown here has a hearth 7 ft. 6 in. outside diameter with a 30-in. column. Chamber height is 15 in. The center column on the hearth of this furnace forms a doughnut-shaped heating chamber. The burners fire tangentially and against the direction of rotation of the table. The drive mech-



anism and the blower are mounted on the base of the furnace making the entire furnace self-contained. The top is a separate structure, removable in one piece. The furnace is suited for continuous operations of either forging or heat treating and can be used for temperatures of 1200 to 2300° F.

For further information circle No. 1688 on literature request card on p. 32-B.

Extensometer

A new high-magnification extensometer for gage lengths of 0.4 or 0.5 in. is now available from Tinius Olsen Testing Machine Co. for 1/16 to 1/2 in. diameter specimens. The 0.4-in. gage length model is recommended for standard 0.113-in. diameter specimens. Extremely light in weight, the Type S-9 electric extensometer is used with the Olsen Model



COMPACT G-E HEATERS FOR BRAZING FIT PERFECTLY INTO NEW STRAIGHT-LINE PRODUCTION SETUP AT THE SACO-LOWELL CO.

Rejects Eliminated in Gun-jacket Assembly

Saco-Lowell Company speeds production, cuts costs with G-E Induction Heaters

"In planning our machine-gun production program, we find G-E induction heaters assure us the high-quality brazing necessary to meet strict Ordnance Department requirements," says F. A. Skinner, Chief Engineer, Edwards Plant, Saco-Lowell Shops, Biddeford, Maine.

At Saco-Lowell, brazing rejects are a thing of the past. Only spot checks are necessary for product inspection, because G-E heaters provide a strong, uniform braze time after time. Saco-Lowell saves on operator training too, because use of these semi-automatic G-E heaters is mastered easily in a few hours.

To learn how you can profitably apply induction heat to your metal processing—in brazing, forging, hardening, or annealing—contact your nearest G-E Apparatus Sales representative today. And write now for new, modern-metal-processing bulletin GEA-5889 on furnace and induction brazing to General Electric Company, Section 720-122, Schenectady 5, N. Y.

GENERAL  **ELECTRIC**

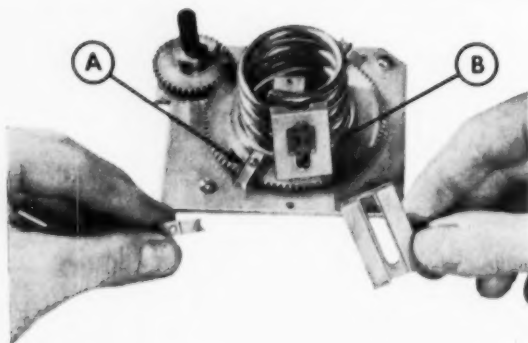
G-E INDUCTION BRAZING



SELECTIVE HEAT produces this clean, strong bond of bearing breach to barrel jacket. Sixty such joints are brazed per hour.

RADIO TRANSMITTER PARTS

Made From Brass Powder



For Quality At Low Cost

The above two parts are A and B in this radio transmitter driver grid. They are pressed from a 90-10 brass powder by American Sinterings of Watertown, Conn., for the Radio Receptor Company to provide the required dimensional accuracy, strength and corrosion resistance at low cost. Perhaps these brass powder applications will suggest some production shortcuts for you.

The larger of the two brass powder parts requires only the drilling and tapping of two end holes prior to plating for assembly. The alternative method of production would undoubtedly be extrusion from bar stock entailing not only the drilling and tapping, but elaborate milling to form the slot and channel (with considerable scrap loss) and a cut-off operation as well. The tolerances held in this powder part are of the order of $\pm .005$.

Production of the smaller part by powder metallurgy involves only the drilling of one hole. If extruded, both ends of the part would have to be milled to achieve the required contours and a cut-off as well as the drilling operation would be necessary.

To provide designers, engineers and metallurgists with a concise reference to the factors which should be considered in designing for powder metallurgy, we—the makers of Horse Head metal powders—have published a 32-page handbook **FACTS ABOUT PRESSED BRASS** and other non-ferrous **POWDER PARTS**. Ask us for a copy.



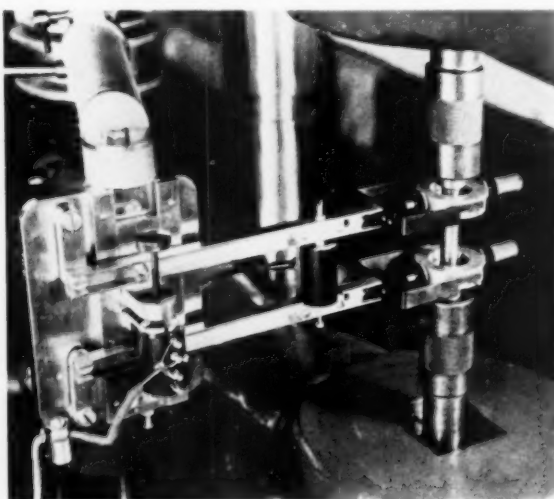
THE NEW JERSEY ZINC COMPANY
160 Front Street • New York 38, New York

51 electronic recorder for detecting strain under both elastic and plastic tension tests. Easily snapped on to the specimen, this small, sensitive instrument is provided with magnifications of 50, 100 and 200. Overall dimensions of the S-9 are approximately $\frac{3}{4} \times \frac{3}{4} \times 1$ in. As the specimen stretches, the activating knife edge on the extensometer moves, which in turn moves the core of the differential transformer. This movement creates an a-c voltage which is amplified to rotate the recorder drum in direct proportion to the strain on the specimen.

For further information circle No. 1689 on card p. 32-B.

Extensometer

A recorder type extensometer designed to produce stress-strain diagrams with high strain magnifications and low magnifications, respectively, below and above the elastic limit of materials has been announced by Baldwin-Lima-Hamilton Corp. Ten strain magnifications

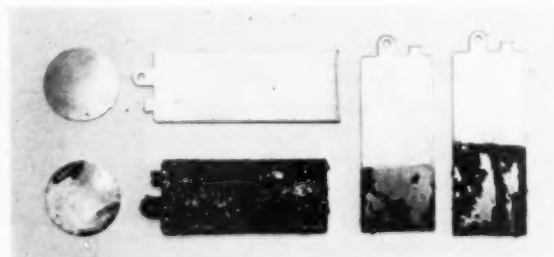


ranging from 5:1 to 200:1 are provided at three positions on extensometer slide and horizontal arms, by the use of extension arms, and by selection of three magnifications. Dual magnification is accomplished by switching. This extensometer can be used on wires, flats, and rounds.

For further information circle No. 1690 on card p. 32-B.

Surface Protection

Results of tests of strippable plastic coatings are shown on these mild steel panels. The surfaces were cleaned, then dipped partially or entirely in a new coating made by Ernst Bischoff Plastics Div. The panels were hung



in test cabinets at 100% humidity, 100° F. for one week. The circular pieces were exposed to outdoor weather for the same time. Dark areas are corrosion product.

For further information circle No. 1691 on card p. 32-B.



1712. Abrasion Tester

Bulletins on durable precision instrument for testing resistance of surfaces to abrasion. *Taber Instrument*

1713. Abrasive Testing

Bulletin No. 6 on methods of running production tests on metal abrasives. *Harrison Abrasive Div.*

1714. Abrasive Wheels

Operating suggestions and recommended wheels for finishing stainless. *Manhattan Rubber Div.*

1715. Adhesives

Bulletin describes polyurethanes and their use in bonding steel to steel, aluminum to aluminum, magnesium to aluminum. *Monsanto Chemical*

1716. Air-Gas Mixer

Bulletin L-700 gives engineering and application data on air-gas proportional mixer. *Eclipse Fuel Eng'g*

1717. Alloy Castings

Data folders on two types of alloy steel castings. Composition, properties, hardenability bands, uses. *Unitcast*

1718. Alloy Castings

8-page bulletin on alloy castings for heat treating. *Ohio Steel Foundry*

1719. Alloy Steel

16-page book on type 9115 low-alloy high-strength steel. Properties, fabrication, welding. *Great Lakes Steel*

1720. Alloy Steel

40-page book on heat treated alloy steel plate for maximum abrasion and impact resistance. Details on uses; 12 pp. of technical data. *Jones & Laughlin*

1721. Alloy Steel

32-page book on abrasion resisting steel. Properties, fabricating characteristics, uses. *U.S. Steel*

1722. Alloy Steel

68-page "Aircraft Steels" book includes revised military specifications. Also stock list. *Ryerson*

1723. Aluminum

8-page folder on aluminum roll formed shapes. *Reynolds Metals*

1724. Aluminum Extrusions

Data on services in the field of aluminum extrusions. *Himmel Bros. Co.*

1725. Aluminum Strip

20-page book gives technical data on five grades of aluminum strip. *Scovill*

1726. Ammonia for Heat Treat

Booklets on "Applications of Dissociated Ammonia", "Ammonia Installations for Metal Treating", "Nitriding Process", "Carbonitriding". *Armour*

1727. Atmosphere Furnace

Booklets H 53-8 on batch-type radiant tube furnaces for gas carburizing, mar-quenching, dry cyaniding, and other heat-treating operations. *Surface Combustion*

1728. Atmosphere Furnace

Information on mechanized batch-type

atmosphere furnaces for gas cyaniding, gas carburizing, clean hardening or carbon restoration. *Dow Furnace*

1729. Barrel Finishing

Bulletin LCC-53-1 on compounds for barrel finishing, descaling, deburring, finishing, coloring and burnishing. *Lord Chemical Corp.*

1730. Bending and Cutting

Folder describes hand and air-operated bender-cutter and its applications. *J. A. Richards*

1731. Beryllium Copper

16-page booklet on applications and properties of beryllium copper. *Beryllium Corp.*

1732. Bimetal Applications

32-page book on application of thermostatic bimetal. Property charts for 30 types. Design formulas. *W. M. Chace*

1733. Black Oxide Finish

Folder on penetrating black finish for ferrous metal. *Puritan Mfg.*

1734. Blackening Stainless

Bulletin on process for blackening stainless steels, cast and malleable irons. *Mitchell-Bradford*

1735. Brass

80-page book on properties and uses of brass forgings, sand castings, rods and machinings. *Mueller Brass*

1736. Brass Foundry

Article discusses sand in the brass foundry. *Lavin*

1737. Brazing

Bulletin 124—on salt bath brazing process—shows how it is possible to substitute brass for copper and develop joints of adequate strength for most steel assemblies. *Ajar Electric*

1738. Brazing Alloys

Bulletin on application of six types of copper and silver brazing alloys. *United Wire & Supply*

1739. Brazing Applications

48-page manual on all aspects of silver brazing applications and problems. *American Platinum Works*

1740. Brazing Stainless Steel

Illustrated booklet, "Bright Annealing, Hardening and Brazing Stainless Steel", describes conveyor furnace and bright brazing alloy. *Sargeant & Wilbur*

1741. Bright Annealing

Reprint on bright annealing of copper in atmosphere furnace. *Holcroft*

1742. Burners

16-page bulletin on selection of gas burners. *Western Products*

1743. Burners

Bulletin 123 on new series of burners for multi-purpose furnaces. *North American Mfg.*

1744. Burners

20-page catalog of oil, gas and combination burners. *Petro*

1745. Carbide Tools

32-page catalog of standard and various

special carbide tipped and solid carbide tools. *Super Tool Co.*

1746. Carbon Control

Technical report on instrument for control of carbon potential of furnace atmospheres. *Lindberg Eng'g*

1747. Carburizing Salts

Folder on salts for liquid carburizing. *Swift Industrial Chemical*

1748. Cemented Carbides

10-page bulletin on use of cemented carbides in wearproofing pulverizing equipment. *Carboloy Dept.*

1749. Cemented Carbides

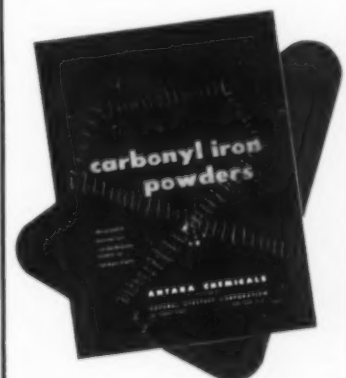
64-page catalog 52 gives latest information on carbide tooling. Completely illustrated details on all types of cutting tools. Handy tables for grade selection and cutting speeds. *Kennametal*

1750. Centrifugal Castings

62-page book on centrifugally cast iron, steel, gray iron parts. ASTM specifications. *American Cast Iron Pipe*

1711 Iron Powders

This 32-page book gives the essential facts of design and powder metallurgy for carbonyl iron powders. Tables and graphs of properties are exceedingly well presented. Design data are plotted as a function of molding pressure and



amount of binder. Electromagnetic data are given for six types of powder. Pertinent mathematical formulas and a complete bibliography of 105 references are included. The book is printed in three colors, which are used to increase the clarity of data presentation, rather than for "splash". *Antara Chemicals*

1751. Chromate Coatings

Folder gives characteristics and uses of chromate conversion coatings on non-ferrous metals. *Allied Research*

1752. Chromium Cast Iron

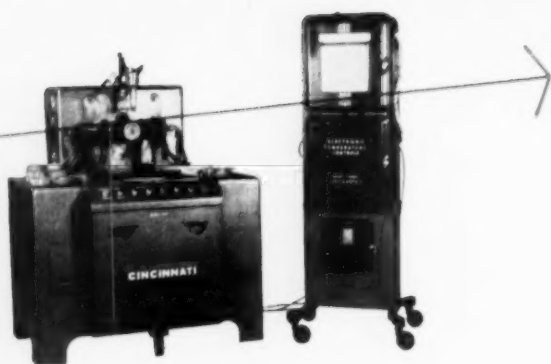
"Abrasion - Resistant High - Chromium Iron" on how to make and use abrasion-resistant iron castings efficiently. *Electro Metallurgical*

1753. Chromium Stainless

Folder on uses of chromium stainless steels; table of analyses and properties. *Lebanon Steel Foundry*

yesterday

It's a far cry from the working model of the early Cincinnati Flamatic hardening machine shown at left to the "do-the-impossible" machines being run off today in the Flamatic Heat Engineering Laboratory. While the early machine hardened small gears in actual production and (among other things) helped to break a critical bottleneck in production of automatic 90 mm. gun loaders . . .

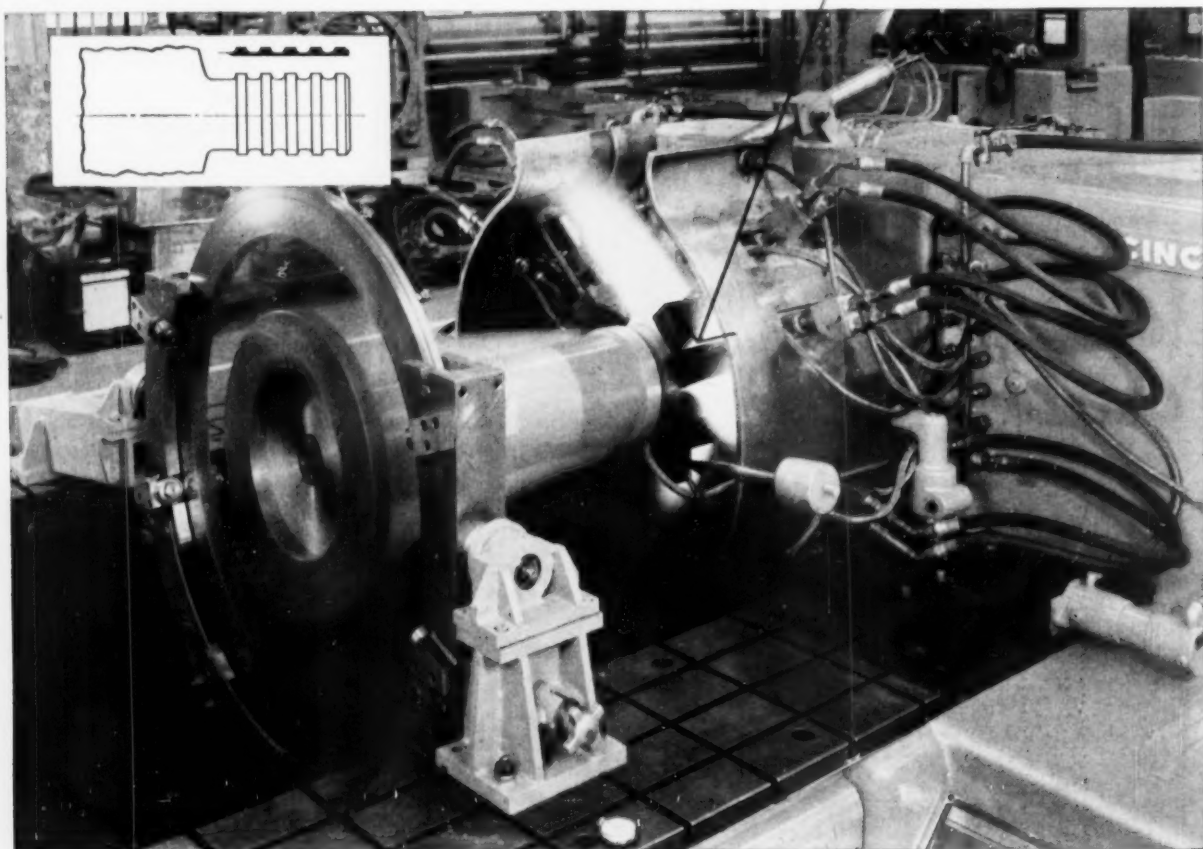


what's new

in flamatic selective surface hardening

today

. . . one of Cincinnati's latest Flamatics (below) is hardening ball retention raceways in the assemblies for mounting propeller blades to go on aircraft we can't talk about. Races must be surface hardened to rigid specifications, before bearings are installed in the large assemblies. The work holding fixture by itself is quite a masterpiece. While Flamatics are getting bigger and more versatile, the original principles still apply: concentrate heat, control temperatures and confine hardness.



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1754. Cleaning Aluminum

12-page bulletin on cleaning process for preparing aluminum and magnesium for welding. *Northwest Chemical*

1755. Coating Aluminum

Bulletin on anodic coating of high hardness for aluminum alloys. *Anodic*

1756. Coatings, Metal

High-vacuum evaporation of metals set forth in detail in 12-page booklet. *Consolidated Vacuum Corp.*

1757. Combustion

Bulletin AD-607 on oxygen index of combustion processes. *Arnold O. Beckman*

1758. Combustion Control

20-page booklet on combustion of various fuels and portable instruments to measure content of oxygen and combustibles. *Cities Service Oil*

1759. Compressors

12-page data book 107-C gives engineering information on characteristics of turbo-compressors. 18 types of application described. *Spencer Turbine*

1760. Contouring

8-page brochure on three-dimensional duplicating facilities for production of airframe sections and dies and molds for metal products. *MPM, Inc.*

1761. Controlled Atmospheres

Bulletin on Dewpointer for reading of atmosphere in field and laboratory. Readily portable, operating on a.c. or enclosed battery. *Illinois Testing Labs.*

1762. Controlled Atmospheres

24-page bulletin describes production problems with reference to dry atmospheres. *Pittsburgh Leetrodryer*

1763. Copper Alloys

64-page book on free-cutting brass, copper and bronze. *Chase Brass*

1764. Core Oils

Bulletin describes core oils, pastes, washes and binders. *Pelron*

1765. Core Ovens

Bulletin 31 on batch-type foundry ovens for ferrous and nonferrous shops. *Despatch*

1766. Corrosion of Copper

28-page booklet B-36 discusses corrosive attack on copper and copper alloys. Tabulation of their relative corrosion resistance. *American Brass*

1767. Corrosion Resistance

32-page brochure on causes of corrosion and means of combatting them. Choice of materials for condenser tubes. *Revere Copper & Brass*

1768. Corrosion-Proof Cement

12-page bulletin gives corrosion resistance of four types of cement vs. 176 chemical solutions. *Atlas Mineral*

1769. Cut-Off Wheels

36-page revised manual on cut-off machines and abrasive wheels. *Norton Co.*

1770. Cutting Fluids

Cutting and grinding fluid selector for various machining operations. *D. A. Stuart*

1771. Cutting Oil

Folder on sulphurized cutting fluid for a wide range of machining jobs. *Gulf Oil*

1772. Degreasing

34-page booklet on vapor degreasing. Design, installation, operation and maintenance of equipment. *Circo Equipment*

1773. Degreasing

Pamphlet on properties and use of trichlorethylene. *Niagara Alkali*

1774. Descaling Process

8-page bulletin on sodium hydride descaling process for ferrous and nonferrous metals. *DuPont*

1775. Dew Point Control

Bulletin No. 21-C on instrument which indicates, records and controls dew point automatically. *Ipsen*

1776. Die Castings

Folder on possibilities and advantages of die castings. *Precision Casting Co.*

1777. Die Steel

"Die Steels for Hot Work" helps in selection of best grade for particular jobs. *Vanadium-Alloys Steel*

1778. Die-Casting Machines

Copies of "Lester Press" describe various features of aluminum die casting machines. *Lester-Phoenix, Inc.*

1779. Drawing Compounds

Folder on lubricant for forming and drawing of stainless. *Hangsterfer*

1780. Ductile Iron Castings

12-page bulletin on pearlitic, ferritic and austenitic grades of ductile iron. 12 typical uses. *American Brake Shoe*

1781. Electric Furnaces

Brochure on electric heat treating, melting, metallurgical tube, research and sintering furnaces. *Pereny Equipment*

1782. Electric Melting

Bulletin 527 on compact arc furnace. Melt time and power consumption for four alloys. *Detroit Electric Furnace*

1783. Electronic Controllers

16-page Bulletin No. B226 on recording controllers for temperature, pressure, flow, liquid level and humidity. *Bristol*

1784. Electropolisher

Bulletin on theory and practice of electrolytic polishing of metallurgical samples. Description of electropolisher. *Buehler*

1785. Extruded Cylinders

Bulletin on extruded steel cylinders

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1786. Extrusion Presses

8-page bulletin on presses designed for extrusion of aluminum, brass and other nonferrous metals. *Lake Erie Engineering*

1787. Fabrication

46-page book shows metal fabrication and production facilities, products and services. *R. C. Mahon*

1788. Fasteners

80 pages of weights and dimensions of nuts, bolts, screws, washers, rivets. *Triplex Screw Co.*

1789. Finishing

Catalog A-654 gives complete story on planning industrial finishing systems and shows many installations of cleaning and pickling machines. *R. C. Mahon*

1790. Finishing

28-page catalog B-9 on corrosion-resistant baskets, racks, crates and tanks

and other fixtures for cleaning and finishing. *Rolock*

1791. Finishing Aluminum

Folder and reprint on an electroless surface conversion process for bonding paint to aluminum and protecting the metal. *American Chemical Paint*

1792. Flow Meters

8-page bulletin on flow meter for furnace installations. *Hays Corp.*

1793. Flow Meters

16-page catalog on meters for flow rate measurement of liquids and gases by variable area method. *Fischer & Porter*

1794. Forgeability

112-page book, "Evaluating the Forgeability of Steels". Hot work characteristics in chart form for 94 steels. *Timken*

1795. Forging Manipulators

Folder on manipulators for automotive, ordnance, aluminum and specialty forging. *Salem-Brosius*

1796. Forming Dies

Folder on styles of forming dies for stainless heads—in wide range of sizes and gages. *Carlson*

1797. Forming Dies

Data on roller dies for forming tubes and rolled shapes. *American Roller Die*

1798. Forming Jaws

Bulletin on Hydra-Curve jaws with flexible action for sheet forming. *Hufford Machine*

1799. Foundry Coatings

Data on colloidal graphite for mold washes, pattern coatings, core coatings, chill coatings. *Acheson Colloids*

1800. Foundry Ovens

Bulletin 30 on conveyor-type forced convection core ovens. *Despatch*

1801. Furnace Belts

44-page catalog describes metal belts for quenching, tempering, carburizing and other applications. *Ashworth Bros.*

1802. Furnace Insulation

Bulletin on ceramic fiber that can give impressive savings compared with high-quality insulating brick. *Refractories Div., Carborundum Co.*

1803. Furnaces

44-page Catalog 112, well illustrated, features furnaces for hardening, tempering, carbonitriding, forge heating, sintering, annealing and tool heat treating. Also atmosphere generators and ammonia dissociators. *C. I. Hayes*

1804. Furnaces

Reprint on forming and heat treating spring harrow teeth at Mid-West Forge & Mfg. Co. *Flinn & Drefflein*

1805. Furnaces

12-page brochure on car furnaces of special and conventional design. *Jet Combustion*

1806. Furnaces

Bulletin describes 18 electric furnaces for research and small-scale production, with operating temperatures to 3000° F. *Harper Electric Furnace*

1807. Furnaces, Heat Treating

32-page catalog on high-speed gas furnaces for heat treating carbon and alloy steels; also pot furnaces for salt and lead hardening. *Charles A. Hones*

1808. Furnaces, Heat Treating

12-page bulletin on conveyor furnace, radiant tube gas heated, oil or electrically heated. *Electric Furnace Co.*

1809. Furnaces, Heat Treating

Catalog on furnaces for tool room and general purpose heat treat. *Cooley*

1810. Furnaces, Heat Treating

Bulletin on fuel and electric furnaces for heat treating. *Dempsey*

1811. Galvanizing

Reprint "Modern Hot-Dip Galvanizing" deals with dross formation as a cause of zinc waste. Detailed information on zinc ammonium chloride type of flux. *Hanson-Van Winkle-Munning*

1812. Gas Carburizing

Bulletin on gas carburizing in rotary furnaces. *American Gas Furnace*

1813. Grainal Steel

6-page article on use of grainal as boron-additive alloy and properties of grainal steels. *Vanadium Corp.*

1814. Hard Surfacing

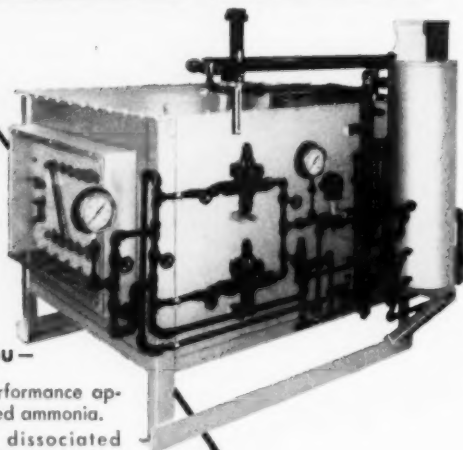
12-page article on selection and evaluation of methods of hardfacing. *Air Reduction Sales*

1815. Hardening Stainless

64-page booklet on Super Scottsonizing

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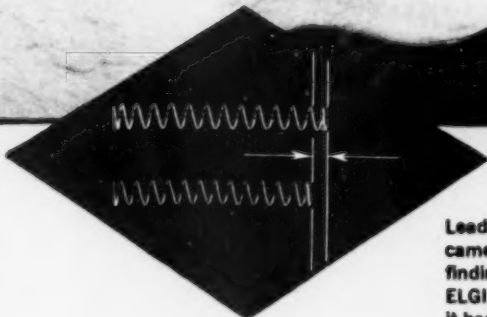


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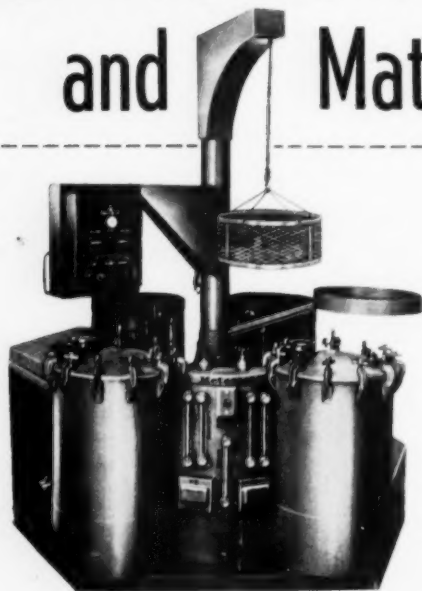
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process of hardening stainless steel. C. U. Scott

1816. Hardness Tester

Literature on Brinell testing machines. Detroit Testing Machine Co.

1817. Hardness Tester

20-page book on hardness testing by Rockwell method. Clark Instrument

1818. Heat Treating

Loose leaf data sheets on heat treating oils, salts, carburizing compounds. Park Chemical

1819. Heat Treating

Brochure on a quick quench aluminum heat treat furnace. James H. Knapp Co.

1820. Heat Treating

Bulletin 850 on shaker-hearth furnace for bright carburizing, carbonitriding, hardening. Hevi Duty Electric

1821. Heat Treating

56-page "Heat Treating Alloy Steels". Republic Steel

1822. Heat Treating

Handy, vest-pocket data book has 72 pages of charts, tables, diagrams and factual data on late steel specifications, heat treatments, etc. Sunbeam

1823. Heat Treating Aluminum

Bulletin 14-T on ovens for heat treatment of aluminum and other low-temperature processing. Young Bros.

1824. Heat Treating Fixtures

24-page catalog on heat and corrosion-resistant equipment for heat treating and chemical processing. 30 classifications of equipment. Pressed Steel

1825. Heat Treating Stainless

84-page book on heat treating stainless steels, both martensitic and austenitic. Republic Steel

1826. Heating Elements

24-page bulletin H on electric heating elements. Includes extensive tabular data on physical and electrical specifications for various sizes. Global Div., Carborundum Co.

1827. High-Temperature Alloys

High temperature work sheet provides valuable suggestions for solving high temperature problems in design and production. International Nickel

1828. High-Temperature Alloys

"Haynes Alloys for High-Temperature Service" summarizes all available data on 10 superalloys and lists physical and mechanical properties of two newly developed alloys. Haynes Stellite

1829. Hydrostatic Testing

Bulletin 353 on three machines for hydrostatic testing on a production-line basis. Steel City Testing Machines

1830. Impregnation of Castings

Literature on new impregnating equipment for elimination of porosity in ferrous and nonferrous castings. Metallizing Co. of America

1831. Indicator

Bulletin 1541 on instrument for the rapid and precise multiple indication of any variable that can be transformed to millivolts. Minneapolis-Honeywell

1832. Induction Heat Control

Sheet 83 on miniature radiation-detecting temperature-measuring device for flame hardening and induction heating. Minneapolis-Honeywell

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METAL PROGRESS; PAGE 26

1833. Induction Heating

Bulletin on new 60-cycle induction furnace for heating aluminum, magnesium, copper and brass for forgings, extrusion and rolling. *Loftus Eng'g*

1834. Induction Heating

Folder on bench-type electronic induction heating generators. *Induction Heating*

1835. Induction Heating

Catalog of heaters, their applications and operation. *Weltronic*

1836. Induction Heating

12-page bulletin 5679 on induction hardening, brazing, annealing at 1000, 3000, and 10,000 cycles. *General Electric*

1837. Induction Heating

Bulletin on low-frequency (60-cycle) induction heating furnace for nonferrous metals. *Magnethermic*

1838. Induction Heating

60-page catalog tells of reduced cost and increased speed of production on hardening, brazing, annealing, forging or melting jobs. *Ohio Crankshaft*

1839. Induction Heating

"Induction Heating" . . . presents case histories of increased production, reduced space, lower costs. *Westinghouse*

1840. Industrial Furnaces

Book 127 on planning expansion, remodeling or modernization of plant. *Continental Industrial Engineers*

1841. Insulating Brick

Bulletin on fire brick and sil-o-cel insulating brick. *Johns-Manville*

1842. Iron-Nickel Alloys

32-page bulletin on austenitic iron-nickel alloys having special thermal expansion or thermo-elastic characteristics. *International Nickel*

1843. Laboratory Furnaces

Data sheets on complete line of laboratory furnaces for metallurgical operations. *Boder Scientific*

1844. Low-Temperature Properties

48-page bibliography of characteristics of steels at low temperature covers 1904 to June 1953. *Inco*

1845. Lubricant

8-page folder describes use of molybdenum disulfide lubricant in cold forming, cold heading and other applications. Case histories. *Alpha Corp.*

1846. Lubricant

New literature on anti-seize molybdenum disulfide lubricant. *Bel-Ray*

1847. Lubricant

40-page booklet on Moly-sulphide lubricant gives case histories for 154 different uses. *Climax Molybdenum*

1848. Machining Alloy Steels

24-page bulletin on economical combination of microstructure, tool form, cutting speed and feed for each machining operation. *International Nickel*

1849. Machining Costs

12-page "Relation of Machining Time to Material Cost". Comparative machinability costs per ton for eleven steels. *La Salle Steel*

1850. Magnesium Applications

60-page book gives 54 case studies on uses. *Dow Chemical*

1851. Malleable Iron

Reprint 51-B on metallurgy, treatment, and heat treated properties of malleable iron. *Surface Combustion*

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Reo engineers needed *top performance* from this new drive shaft . . . so they insisted on STRESSPROOF! They knew from years of successful experience with STRESSPROOF that it could take abuse. It had both the strength and wearability to stand up under the toughest service—and its excellent machinability was most welcome from a cost standpoint.

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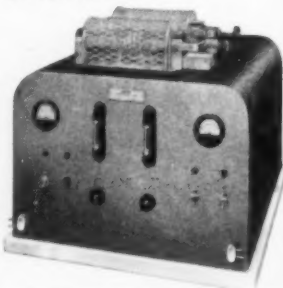
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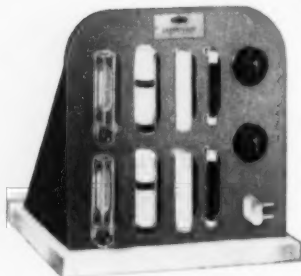


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METAL PROGRESS; PAGE 28

1852. Meehanite Castings

8-page bulletin on five engineering grades of Meehanite. Hardenability, other properties, uses. *American Brake Shoe*

1853. Metal Cleaners

Bulletin B-8 gives tabular data on 15 metal cleaners. *Apothecaries Hall*

1854. Metal Detector

Catalog on detector for any kind of metal or alloy. *RCA*

1855. Metal Cutting

64-page catalog No. 29 gives prices and describes complete line of rotary files, burrs, metalworking saws and other products. *Martindale Electric*

1856. Metal Finish

Bulletin 531 on silicone-base heat-resistant finish. *Midland Ind. Finishes*

1857. Metallizing

New bulletin on applications of metal-spraying and torch-fusing method of hard surfacing. *Metallizing Engineering*

1858. Metallograph

Metallograph, described in catalog E-240, furnishes four different accurate images of same sample for complete identification with bright field, dark field or polarized light. *Bausch & Lomb*

1859. Microhardness Tester

Bulletin describes the Kentron microhardness tester. *Kent Cliff Laboratories*

1860. Microscopes

22-page catalog describes microscopes featuring ball bearings and rollers throughout the focusing system and a low-position fine adjustment, providing comfortable operation. *Bausch & Lomb*

1861. Nitrogen Atmosphere

Bulletin on generator for producing pure nitrogen with a controllable hydrogen content. *Baker & Co.*

1862. Nondestructive Testing

Bulletin on latest ultrasonic testing equipment and techniques. *Sperry Prod.*

1863. Nondestructive Testing

Series of bulletins gives data on both ultrasonic and magnetic testing instruments. Illustrated. *J. W. Dice Co.*

1864. Nonferrous Tubing

Bulletin on seamless, brazed and lock-seam tubing in brass and copper. *H & H Tube and Mfg.*

1865. Oil Quenching

Catalog V-1146 on self-contained oil cooling equipment. Selection tables for volume of oil required and oil recirculation rates. *Bell & Gossett*

1866. Oil Quenching

8-page brochure tells in detail how carbon steel often can replace alloy steel when additive is used in the quenching oil. *Aldridge Industrial Oils*

1867. Openhearth

Brochure on modern openhearth design and construction. *Loftus*

1868. Paint Spraying

Folder on ionic gun and ionic high potential paint spraying equipment. *Scientific Electric*

1869. Peening

Bulletin on use of cut wire shot for peening and cleaning. *Park Chemical*

1870. Periodic Chart

Latest periodic chart of the elements. Green and black, 11 by 14 in., official 1952 data. *General Electric*

1871. Phosphate Coating

12-page "Phosphate Coating Chemicals

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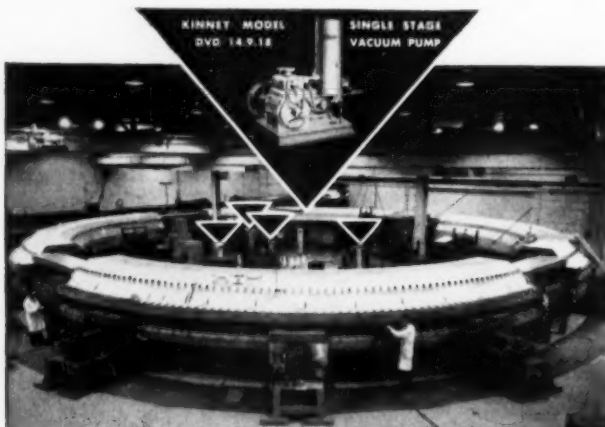
This latest and most nearly accurate Hardness Conversion Chart is a necessity wherever hardness testing is done. It has been compiled and produced by CLARK, makers of the internationally respected CLARK Hardness Tester for "Rockwell Testing." Printed on heavy stock convenient for wall mounting, the chart is offered free of charge to hardness tester users. Just attach this ad to your letterhead or write "Send wall chart." A copy will be mailed to you without charge or obligation.

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METAL PROGRESS; PAGE 30

and Processes" gives data on paint bonding, rust proofing, protecting friction surfaces, improving drawing and extrusion. American Chemical Paint

1872. Phosphating

Pamphlet A-108 on phosphating materials. Phosphating reference chart included. Turco Products

1873. Pickling Baskets

12-page bulletin on mechanical picklers, crates, baskets, chain and accessories. Youngstown Welding & Eng'g

1874. Pipe Standards

48-page booklet on codes and standards for piping and pressure vessels. Taylor Forge

1875. Plating

8-page booklet on plating rack designed to make spline section or body of rack a permanent tool. National Rack

1876. Plating Solutions

Bulletin 12 on electric heating of pickling and plating solutions. Pyrosil

1877. Powder Metallurgy

32-page handbook gives 24 case histories of parts designed or redesigned for powder metal production. Cost comparisons; definitions of terms and list of standards. New Jersey Zinc

1878. Precision Casting

8-page bulletin on investment castings of various ferrous and nonferrous alloys. Engineered Precision Casting

1879. Precision Casting

Bulletin on mechanically-operated induction furnace for precision casting. Ajax Electrothermic

1880. Precision Casting

44-page Catalog 53 covers every stage of the investment casting process. Alexander Saunders

1881. Precision Casting

Bulletin 706 on the Mercast frozen mercury process of investment casting. Alloy Precision Castings

1882. Precision Forgings

Data folder on small metal parts forged to within a few thousandths. Utica Drop Forge

1883. Presses

Bulletin No. 45 on recommendations for modernization and conversion of old presses. E. W. Bliss

1884. Pyrometer Supplies

Buyers' Guide for pyrometer supplies. No. 100-5. Minneapolis-Honeywell

1885. Quenching

Bulletin 120 on use of heat exchangers to provide heat control in quenching bath. Niagara Blower

1886. Quenching

"Handbook on Quenching" gives complete information. E. F. Houghton

1887. Quenching

Data sheet on mixer for agitation of quenching liquids. Chemineer

1888. Rare Earths

8-page Progress Report Number 1. "Rare Earths in Iron and Steel Melting". Molybdenum Corp.

1889. Recorder

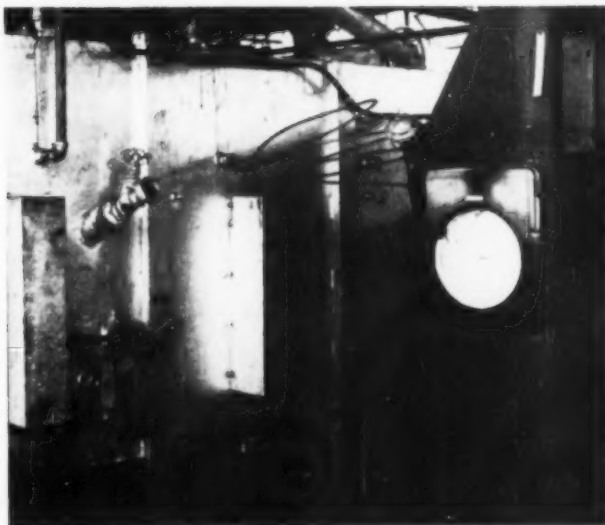
Bulletin C2-2 on electronic strip chart recorder for temperature, speed, static strain, voltage, amperage. Wheelco

1890. Recorder Controllers

48-page ND 46(1) gives specifications, installation pictures of recorders and controllers for temperature, strain, other variables. Leeds & Northrup
(Continued on p. 32-A)

BETTER REGULATION OF FURNACE GAS GENERATORS

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DEW POINT RECORDING
of controlled
furnace atmospheres**

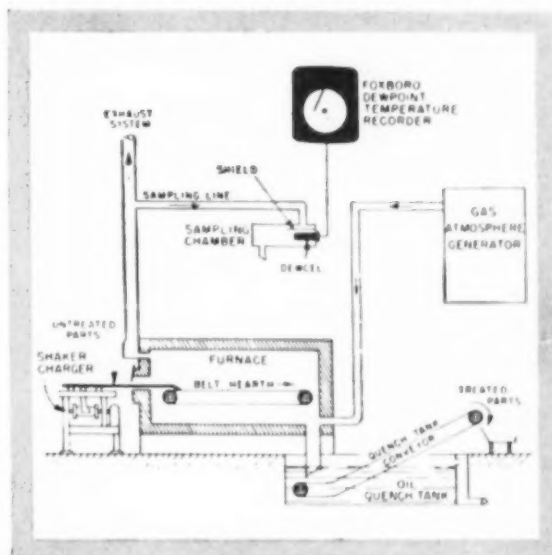


Typical installation of Foxboro Dew Point Recorder on Westinghouse controlled-atmosphere furnace at Champion De Arment Tool Co., Meadville, Pa. Diagram shows simplicity of system and hook-up.

Now you can get positive information to prevent decarburizing, etching, scaling and carbon deposit caused by incorrect moisture in your controlled-atmosphere furnaces. And all it takes is the moderate cost of a single instrument!

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DECEMBER 1953, PAGE 31

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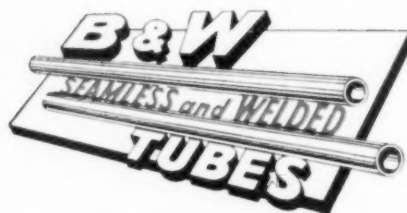
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TA-1750(M)



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METAL PROGRESS; PAGE 32-B

(Continued from p. 30)

1891. Refractories

Form 1409 on fused stabilized zirconia refractory for furnace linings, metal melting, other uses. Norton Co.

1892. Refractory Cement

Data on castable cement for temperatures to 3100° F. Refractories Div., Carborundum

1893. Resistance Testing

Bulletin 100 on production tester for measuring electrical resistance. Rubicon

1894. Resistance Welding

16-page book on steps in making a resistance weld, metals suitable and controls. General Electric

1895. Resistors

Data sheets on use of heat sensitive electrical resistor for temperature compensation and controlled automation. Carbonyl Dept.

1896. Rivets

12-page catalog on blind rivets. Applications, specifications, types, descriptions. Townsend Co.

1897. Roll Formed Shapes

24-page Bulletin 1053 on designing, forming and producing shapes from ferrous and nonferrous metals. Roll Formed Products Co.

1898. Rust Preventives

12-page bulletin on water-soluble rust-preventive. Production Specialties

1899. Salt Bath Descaling

12-page bulletin B-40 describes continuous and batch descaling lines for removing oxide from steel, bronze, copper, stainless and titanium. Drever

1900. Salt Baths

28-page book deals with heat treatment, carburizing, bath maintenance, safety precautions. American Cyanamid

1901. Sand Control

32-page book on defects and troubles in foundry and how to remedy through sand control. Claud S. Gordon Co.

1902. Saws

Catalog C-53 describes 35 models of metal-cutting saws. Armstrong-Blum

1903. Screw Thread Inserts

16-page book of design data and specifications on screw thread bushings of helically coiled wire, for aluminum, magnesium, iron, steel. Heli-Coil Corp.

1904. Shell Molding

Folder on principal features of shell molding machine. Shalco

1905. Shot and Grit

Handy calculator has size data for SAE grades of shot and grit. Pangborn

1906. Shotblasting

16-page "Primer on the Use of Shot and Grit." Problems of blast cleaning operations. Hickman, Williams

1907. Silver Brazing

Series of eight technical bulletins on silver brazing. Joint strength, design, stress analysis, heat treatment, fluxes. Handy & Harman

1908. Sintered Carbides

Catalog of made-to-order tungsten carbide components gives typical shapes and sizes. Sintercast Corp.

1909. Soldering Aluminum

6-page folder on use of a noncorrosive flux for soldering aluminum. Data on joint strength and ductility. Insulation and Wires, Inc.

1910. Soldering Equipment

8-page brochure on soldering and brazing equipment describes new Mogul soldering gun and shows its applications to production-line soldering and brazing. Metallizing Co. of America

1911. Spark Testing

20-page spark test guide features spark diagrams of 13 standard tool and die steels. Carpenter Steel

1912. Spectrograph

16-page catalog G2-53 describes grating spectrographs for precision analysis. Jarrell-Ash

1913. Spring Alloy

Data on Elgiloy. Industrial uses, properties, special features. Abrasives Div., Elgin National Watch

1914. Stainless Castings

Technical data chart gives designations, composition, mechanical and physical properties. Cooper Alloy Foundry

1915. Stainless Fastenings

20-page catalog of stainless steel cap screws, nuts, washers, machine screws, sheet metal screws, set screws, pipe fitting and specialties. Star Stainless Screw

1916. Stainless Steel

44-page book gives detailed information

on use of stainless steel in the industries. Crucible Steel

1917. Stainless Steel

Slide chart. Set top at a certain casting operation, bottom shows next each standard grade. On revery heat treating and corrosion data and Carpenter Steel

1918. Stainless Steel

Bulletin gives examples of five stainless steel castings. Sirger

1919. Stamping Tester

Reprint on equipment for determining the drawability of sheet steel. Stamping Testing

1920. Standardization

24-page booklet defining standard production and their value as management. American Standard

1921. Steam Generators

20-page booklet on the six basic generating units and allied equipment. Union Iron Works

1922. Steel Plate

Bulletin 901 on steel plate for carburizing, heat treating and many uses illustrated. W. J. Hol

1923. Steel Tubing

48-page Handbook F-3 on fabrication and forging steel tubing. Bending, cutting and joining operations. Ohio Seamless Tube

1924. Stress Relieving

Bulletin 650 on car-bottom, continuous type furnace for stress relieving

1925. Stress-Rupture

Data Card 153 gives stress-rupture for nine grades of stainless. Bal Wilcox

1926. Subzero Treatment

12-page bulletin on subzero treatment of tool steel and increase in tool life. Sub-Zero Products

1927. Super High Speed

Folder on molybdenum, 8% cobalt speed steel for use at speeds 20% greater than with ordinary high speed steel. Heat treatments, protective coatings and uses. Firth Sterling

1928. Surface Pyrometer

Bulletin 185 on instrument for accurate readings of surface temperatures. Pyrometer Instrument

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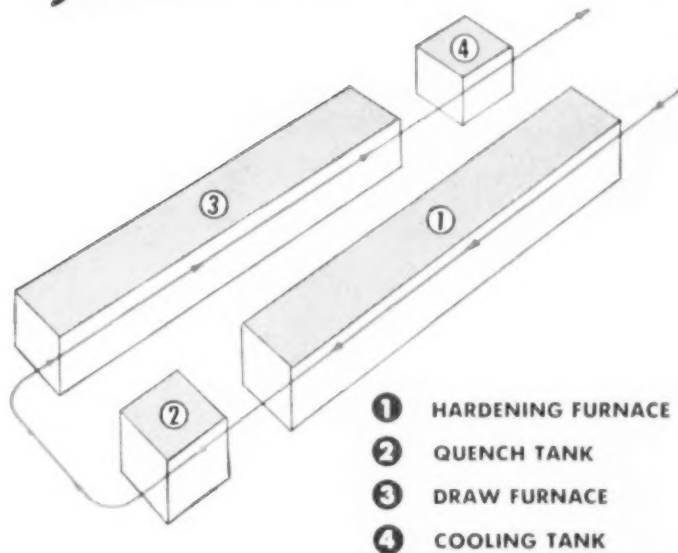
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CANADA
Walker Metal Products, Ltd.
Windsor, Ontario

EUROPE
S. O. F. I. M.
Paris 8, France

1929. Surface Treatment

Bulletin No. 51 on methods of treating metal surfaces with peroxygen compounds. *Buffalo Electro-Chemical*

1930. Temperature Control

Bulletin 50H describes thermocouple pyrometer controller. *Thermo Electric*

1931. Tempering

Bulletin IE 11 on tempering and other applications in liquid baths. *Kemp*

1932. Testing Machines

32-page catalog on hydraulic testing machines 10 models described; also accessories. *Riehle*

1933. Testing Machines

8-page folder on Ansler machines for tests in tension, compression, torsion, shear, fatigue, bending and ductility. *A. I. Buchler*

1934. Textured Metal

Bulletin describes Armoply, a composite of plywood and textured metal. *U. S. Plywood Corp.*

1935. Thermocouples

36-page Bulletin 235-4 describes various types of thermocouples, extension wire and other accessories. *Foxboro*

1936. Thermocouples

44-page catalog EN-S2 describes couples and assemblies for general application and for special plant and laboratory uses. Tabular data on accuracy and limits of couples. *Leeds & Northrup*

1937. Thermometers

16-page bulletin describes dial thermometers for long distance measurement. *Foxboro*

1938. Tin

Monthly newsletter, "Tin News," gives information about prices, supply, demand. *Malayan Tin Bureau*

1939. Titanium

30-page data book on properties of commercially pure and alloy titanium, melting, forging and rolling. 16 charts and micrographs; 4 hardness conversion curves for titanium. *Republic Steel*

1940. Tool & Die Steels

28-page guide to qualities and sizes available. *Uddeholm*

1941. Tool Heat Treating

Information on "Sure-Wear" process for heat treating high-speed cutting tools. *L.R. Heat Treating Co.*

1942. Tool Material

28-page booklet on tungsten, chromium, cobalt alloy, its properties and types of tools made from it. *Vasecoloy-Ramet*

1943. Tool Steel

Folder on high carbon, high vanadium tungsten base high speed steel. *Latrobe*

1944. Tool Steel Failures

124-page book, "Tool Steel Trouble Shooter", analyzes 107 tool failures and assigns causes as among tool design faults, tool steel faults, improper heat treatment, mechanical and operational factors. *Bethlehem Steel*

1945. Tubing

8-page booklet on stainless, nickel and nickel alloy tubing and small tool specialties. *J. Bishop & Co.*

1946. Tubing

24-page catalog on large diameter, corrosion resistant pipe, tubing and welded fittings. Tolerances, weight tables, grades, alloys and other data. *Stainless Welded Products, Inc.*

1947. Tubing

Bulletin 32 on analyses available, production limits, commercial tolerances, temper designations of seamless and welded tubing. *Superior Tube*

1948. Tungsten Electrodes

Wall chart gives data for inert-gas arc welding of aluminum, magnesium, stainless steel with pure and thoriated tungsten electrodes. *Sylvania*

1949. Universal Machine

8-page Bulletin 118 on a universal machine tool on which more than 50 different operations can be performed. *Newage International*

1950. Vacuum Finishing

Use of vacuum metallizing in manufacture of plastic and metal parts. *National Research Corp.*

1951. Vacuum Gage

Folder GEC 986 on molecular vacuum gage for measuring pressures without external detectors. *General Electric*

1952. Vacuum Pumps

24-page Bulletin V51 on high-vacuum pumps and accessories. *Kinney Mfg.*

1953. Valves

50-page booklet on valves for the process industries. *Gas Machinery*

1954. Weight Computer

Computer for weights of strips, sheets, bars and plates of various metals and alloys. Also basic specifications for fabrication of pressure vessels. *Continental Copper & Steel Industries*

1955. Weld Strength

Calculator indicates size of weld required for an applied load and weight of a given length of weld. *Lukens Steel*

1956. Welding

3 bulletins on recently developed filler-arc consumable-electrode gas-shielded welding process. *General Electric*

1957. Welding Alloy Steel

44-page Data Book 4D covers all types of welding of nickel alloy steel. *International Nickel*

1958. Welding Electrodes

Bulletin on electrode selection for welding stainless and alloy steels. *Arco*

1959. Welding Equipment

Catalog on Cadweld process and arc-welding accessories. *Erico Products*

1960. Weld-Rod Dehydrating

Bulletin on low-hydrogen electrode stabilizer. Specifications of equipment for dehydrating mineral shielding on low-hydrogen electrodes. *Archer*

1961. Wet Blasting Equipment

8-page folder on high velocity, pressure blasting. *Cro-Plate*

1962. Wire Baskets

84-page book on fabricated baskets for dipping and heat treating. *Cambridge Wire Cloth*

1963. X-Ray Analysis

8-page booklet of questions and answers on X-ray analysis. *North American Philips*

1964. X-Ray Diffraction

Analytical applications of X-ray diffraction using direct measurement techniques. *X-Ray Dept., G.E.*

1965. X-Ray Inspection

248-page catalog and supplement on materials used in X-ray inspection. *Pickering X-Ray*

1966. Zirconium

26-page booklet gives physical, mechanical and chemical properties, present and potential uses, supply and prices of zirconium. *Zirconium Metals*

December, 1953

1672	1697	1722	1747	1772	1797	1822	1847	1872	1897	1922	1947
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regular analysis high speed steels

...plus...

NEW SULPHIDE LUBRICANTS

**... Additives
made possible**

**by the "DESEGATIZED" process
now available in M-1, M-2 and M-10 types**

*Lower Costs through
Higher Production*

Contact your local Latrobe
representative for further information.

^{*}Patent applied for.

Latrobe
STEEL COMPANY
LATROBE, PENNSYLVANIA

SALES OFFICES AND WAREHOUSES
BOSTON BUFFALO CHICAGO CLEVELAND DAYTON DETROIT HARTFORD HILLSIDE
LOS ANGELES MILWAUKEE PHILADELPHIA PITTSBURGH ST. LOUIS TOLEDO

SALES AGENTS
DALLAS DENVER HOUSTON SALT LAKE CITY SEATTLE WICHITA

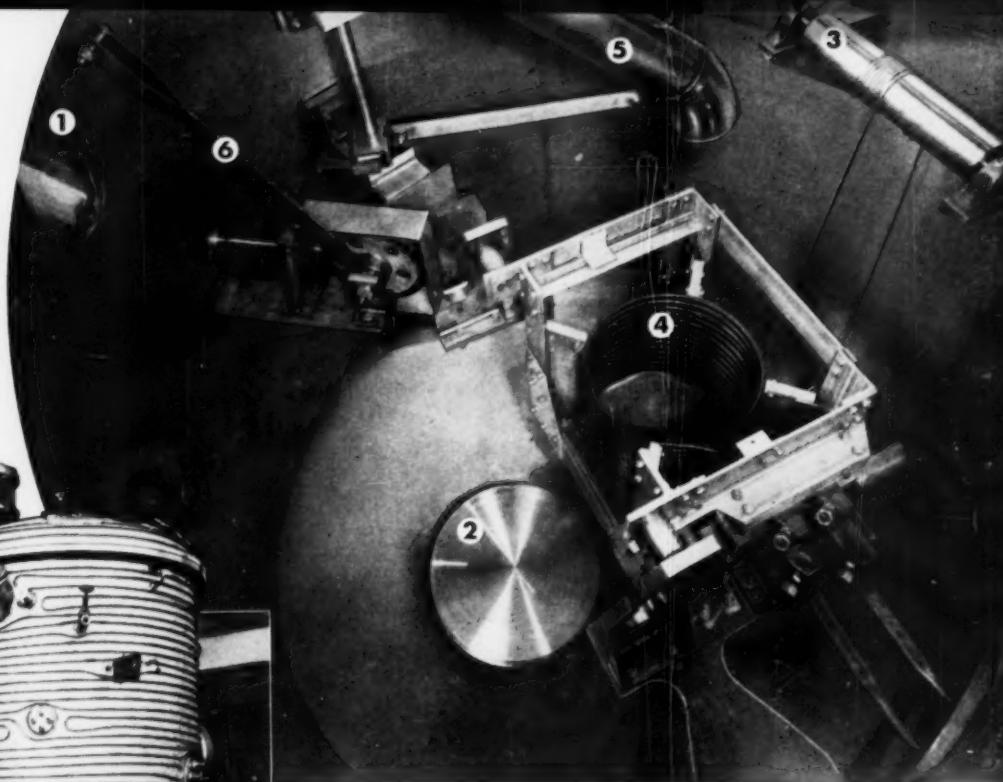
EUROPEAN OFFICES IN
GENEVA BRUSSELS MILAN PARIS ROTTERDAM

These features are standard
in a CVC vacuum furnace

- ① Sight window
- ② Properly located mold port
- ③ Simple windless for tilting furnace
- ④ Power-saving induction heating assembly
- ⑤ Alloy addition device
- ⑥ Externally operated crucible cover lift



*CVC's sixty-six inch high vacuum
melting and casting furnace*



The Metallurgist's work shop...

a **CVC** high vacuum furnace

When you invest in a *high vacuum* furnace, you want to buy—versatility—good mechanical and electrical design—and a *vacuum system* that will *pump to* and *hold at* the desired pressure, no matter what the gas load.

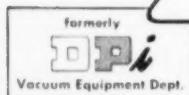
This is exactly what you receive in a *CVC high vacuum* furnace. CVC, with years of engineering experience in the high vacuum field, has solved such problems as producing vacuum tight seals, providing insulation under vacuum,

handling the volatile components of the melt, and adding to the melt.

Whether you need a *high vacuum* furnace for laboratory or production use, CVC can meet your requirements. Feel free to consult with our metallurgical experts. *Consolidated Vacuum Corporation; Rochester 3, New York.* (A subsidiary of Consolidated Engineering Corporation, Pasadena, California.)



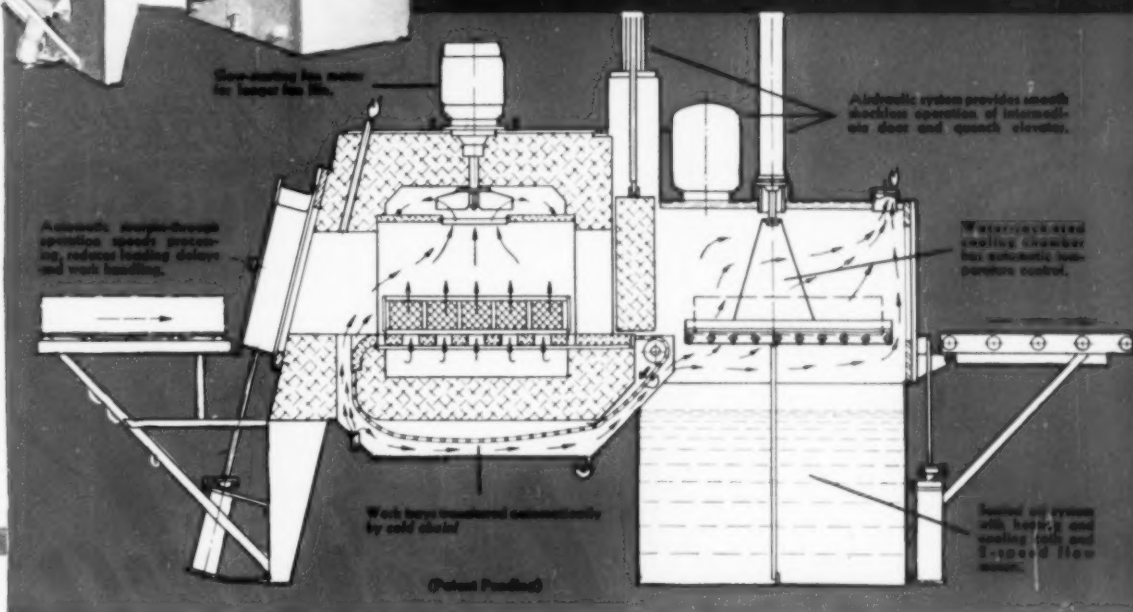
Consolidated Vacuum Corporation
Rochester 3, N. Y.



designers and manufacturers of high vacuum equipment
SALES OFFICES: PALO ALTO, CALIF. • CHICAGO, ILL. • CAMDEN, N. J. • NEW YORK, N. Y.



YOU GET *Uniform Results* with Ipsen 100% FORCED CONVECTION CONTROLLED ATMOSPHERE UNITS



- 1 Heat and quench signal lights
- 2 Automatic temperature recorder
- 3 Heating cycle timer
- 4 Quench timer
- 5 Hi oil flow timer
- 6 Selector switch for air or oil
- 7 Cycle start button

SIMPLE CHANGE-OVERS

Change-over from one process to another is simple, quick, and easy. Settings for heat, atmospheres, quench, and oil flow is all that is required. Cycle is then controlled automatically.

★Above is a cross-section view of the Ipsen 400 Lb./Hr. Furnace showing the advanced design features which have made Ipsen the largest manufacturer of carbonitriding and batch-type heat treating units. With these new units, you get the advantages of 100% forced convection heating and controlled atmosphere processing, *plus* the full benefits of automatic straight-through operation. Thus, you eliminate loading delays and guess-work. You control distortion and get uniform results from batch to batch . . . today, tomorrow, or next year. You eliminate blasting and pickling operations and you can often use lower grade, less costly steels.

A SINGLE UNIT HANDLES ALL OF THESE OPERATIONS

Unusually versatile, the Ipsen is built for temperatures up to 1850° F., and a single unit is equipped to handle all of the following processes:

ATMOSPHERE COOLING

Normalizing
Stress Relieving
Carburizing
Carbonitriding

OIL QUENCHING

General Hardening
Carburizing and Hardening
Carbonitriding
Martempering

Send Samples for Free Estimate—find out how the new Ipsen Units can be applied to your job. Samples of your work will be run, procedures established in our new, modern lab, and cost estimates given without obligation.

Write for New Literature—illustrates new design features, gives complete specifications of various units.



MORE THAN 375 IPSEN HEAT TREATING
UNITS ARE NOW SERVING INDUSTRY



IPSEN INDUSTRIES, INC. 723 South Main Street; Rockford, Illinois
Universal Units to CARBONITRIDE • CARBURIZE • HARDEN • BRAZE • MARTEMPER • WASH • TEMPER

your best buy

for all
your metal
degreasing



and here's why!

ALL-PURPOSE—Removes from metal parts practically every kind of foreign matter—waxes, oils, greases, gums, tars, chips.

QUICK ACTING—Cleans and dries rapidly. Low boiling range (86.6°-87.8°C, based on standard ASTM tests) permits vaporization at low steam pressure.

THOROUGH—Low viscosity (0.58 centipoises at 20°C) and low surface tension (about 29 dynes per cm at 30°C) assure diffusion into pores and relatively inaccessible openings.

SAFE—Has neither flash point nor fire point; classed as nonflammable at room temperatures, only moderately flammable at higher temperatures (Underwriters' Laboratories rating 3).

CUTS POWER CONSUMPTION—Can be heated by either gas, steam or electricity. Gives concentrated vapor at only 188°F. Specific heat less than $\frac{1}{4}$ that of water.

CUTS VAPOR LOSS—High vapor density (4.5 times that of air) assures proper vapor level at all times.

STABLE—Neutral stabilizer gives protection not only in the liquid but also in the vapor.

ECONOMICAL—Completely re-usable after distillation. And whether you buy by the drum or the carload, you pay no extra premium.

A request, written on your company letterhead, will bring you a free copy of our new Nialk TRICHLORethylene booklet.

NIAGARA ALKALI COMPANY

60 East 42nd Street, New York 17, New York

NIALK® Liquid Chlorine • NIALK Caustic Potash • NIALK Carbonate of Potash • NIALK Paradichlorobenzene
NIALK Caustic Soda • NIALK TRICHLORethylene • NIAGATHAL® (Tetrachloro Phthalic Anhydride)

A FEW WELL KNOWN AJAX USERS

A. C. Spark Plug Division
Brown & Sharpe Mfg. Company
Commercial Steel Treating Company
Henry Disston & Sons Company
Ford Motor Company
Frigidaire Division
General Electric Company
Gorham Tool Company
Greenfield Tap & Die Company
Landis Machine Company
Midvale Company
Morse Twist Drill Company
Mueller Brass Company
National Cash Register Company
National Screw Company
Oliver Iron & Steel Company
Pratt & Whitney Division
Republic Steel Company
Stanley Works
Thompson Products Company
Thompson Tap & Die Company
Union Twist Drill Company
Wheeler Steel Treating Company
Widgish Electric Company
... and dozens of others

THE Preferred Practice FOR HARDENING TOOLS AND DIES

(High Speed, High Carbon-High Chromium, Stainless and Carbon Steels)

When such an imposing array of the world's leading makers of high speed tools and dies adopt the same heat treating method and equipment, you can count on it that there's a reason—several reasons in fact.

Productive capacity is two or three times that of other heat treating methods because of faster heating.

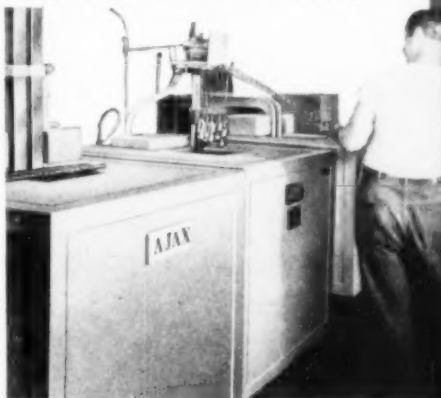
Distortion is negligible.

Surface protection is unsurpassed—because the salt bath seals the work *automatically* from all atmosphere. Scaling, decarb and pitting are avoided.

Temperature control is closer, more accurate. The temperature will not vary more than $\pm 5^\circ\text{F}$ anywhere in the bath.

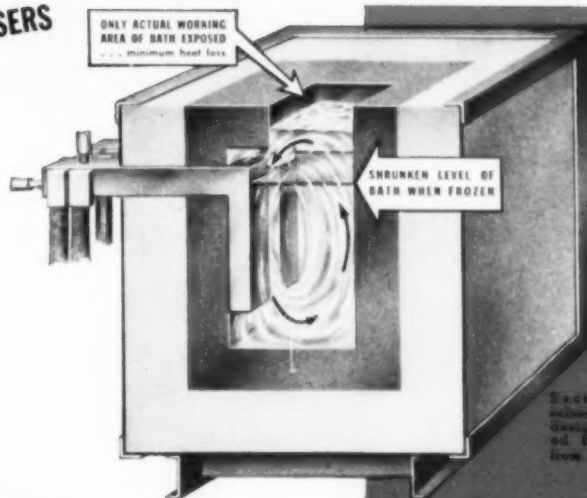
The life of tools is increased from 25% to 300% over those heated by ordinary methods.

Adaptability—The Ajax Salt Bath handles any type of high speed, carbon or



Typical installation for hardening high speed tools. Preheat, high heat and quench furnaces. The center unit operating at 2350°F is equipped with submerged electrodes (see illustration at upper right). Preheat and quench units have suspended electrodes.

alloy tool and die steel. Moreover, it occupies less floor space, does not require a skilled operator and provides maximum protection and long life for pots.



Sectional view of submerged electrode design recommended for operations from 1700°F to 2300°F .

Through this unique and patented Ajax submerged electrode design, the efficiency of salt bath hardening is increased in the following ways:

Power Consumption Decreased as Much as 30%—Only the actual working area of bath exposed.

Electrode Life Greatly Extended—Electrodes not exposed to severe oxidizing action at surface of bath.

Bath Rectification Simplified—Oxides and dross materially reduced due to restricted bath surface.

Restarting is Easy—Closely-spaced electrodes melt salt from top downward. No danger of sealed in pressure. No damage to pot or electrodes.

Accurate Temperature Control—Electrodynamic action insures temperature uniformity within $\pm 5^\circ\text{F}$ throughout bath.

Overheating of Work Eliminated—Electrodes closely spaced, set against back wall of furnace, prevent heating current from entering work. Entire bath depth available for work.

Salt Leaks Prevented—Complete outer steel casing.

Easier Charging and Discharging—Furnace top is unobstructed.

Write for Ajax Bulletin 123B

AJAX ELECTRIC COMPANY, INC.

910 Frankford Ave., Philadelphia 23, Pa.

THE WORLD'S LARGEST MANUFACTURER OF ELECTRIC HEAT TREATING FURNACES EXCLUSIVELY

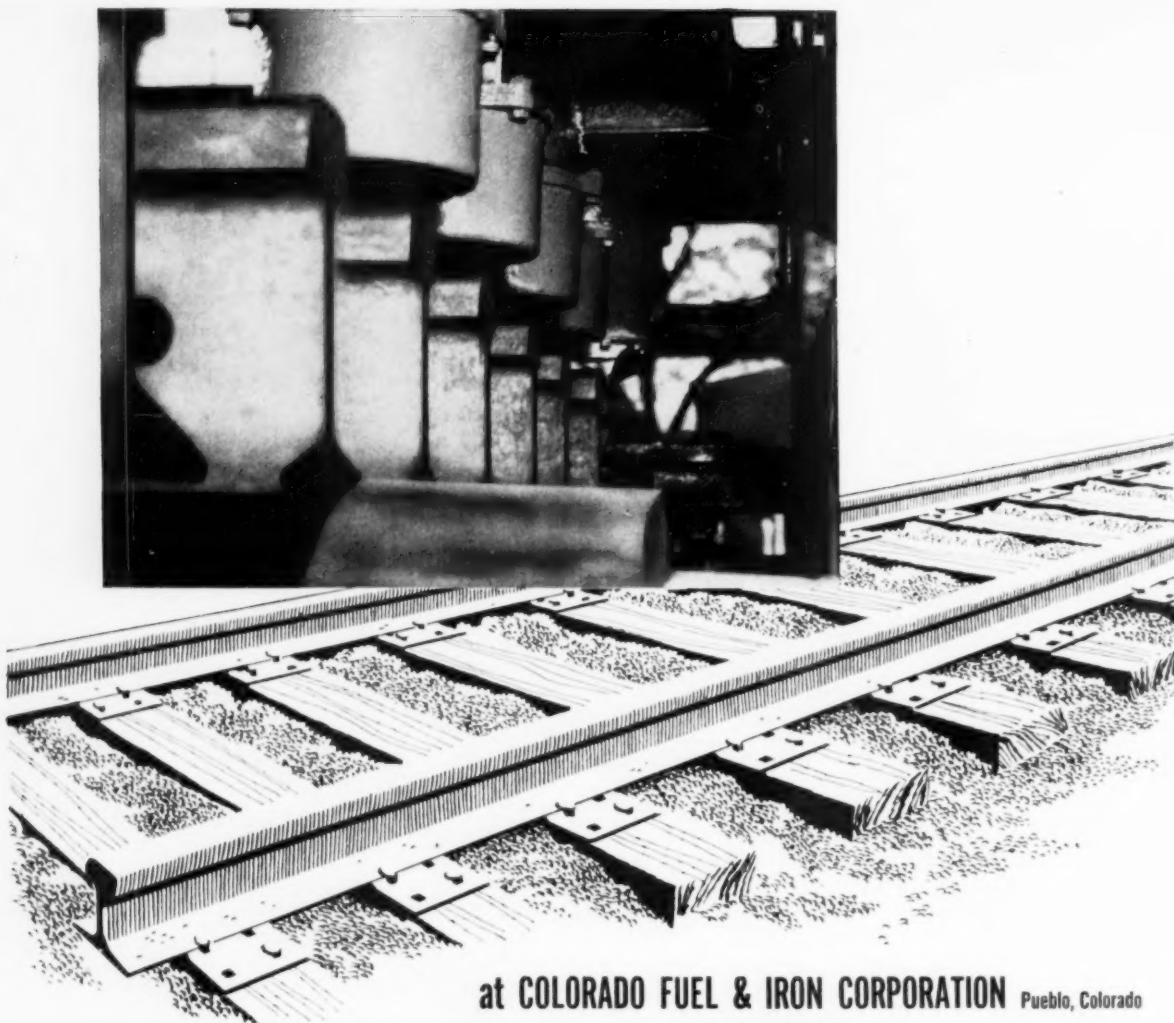
In Canada: Canadian General Electric Co., Ltd., Toronto, Ont.

Associate Companies: Ajax Electric Furnace Corp.
Ajax Electrothermic Corp. • Ajax Engineering Corp.



AJAX

ELECTRIC SALT BATH FURNACES



at COLORADO FUEL & IRON CORPORATION Pueblo, Colorado

high speed processing with **GAS** produces longer lasting rails

The essential role of GAS as a production-line tool is particularly well demonstrated in the manufacture of railroad rails at Colorado Fuel and Iron Corporation, Pueblo, Colorado.

This process involves the use of GAS-fired radiant burners, with automatic cycle-timing devices, to harden the ends of the finished rails as they move out of the mill.

First the rails are pre-heated by GAS to 1000° F. Then the ends are heated by high intensity GAS radiants which automatically bring the temperature to 1600° in 95 seconds. Finally, a cold air blast

quenches and hardens the ends. This hardened area covers the entire rail width to a minimum depth of $\frac{1}{4}$ " and extends back from the end about 1½".

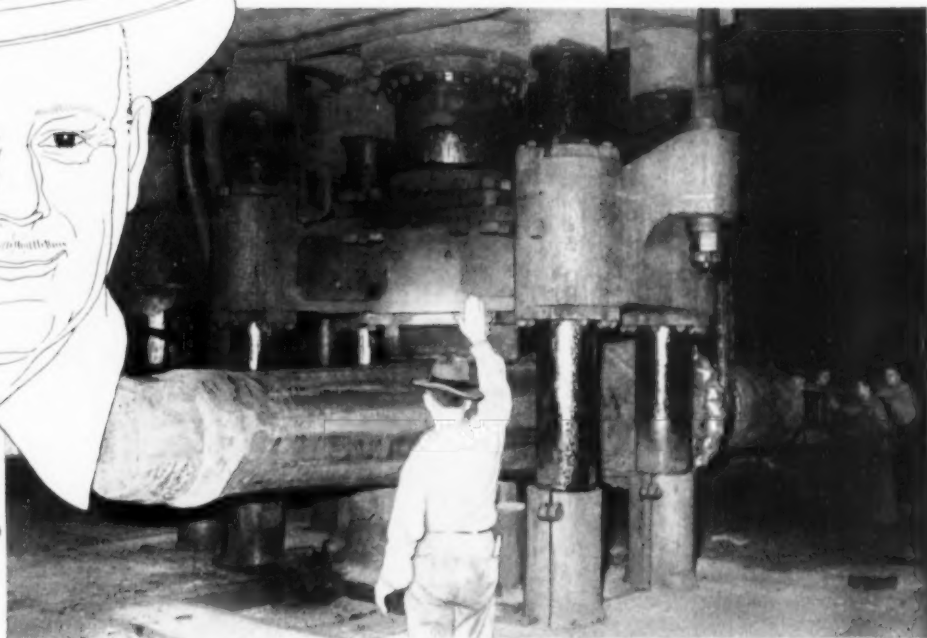
High-speed heat processing with GAS results in longer rail life, lower maintenance costs, and greater safety for the railroads. The installation is one of thousands of *precision-tool* applications of GAS for exacting metallurgical requirements. If you would like further information on how GAS and Modern Gas Equipment increase efficiency, reduce costs, and improve products throughout industry, call your Gas Company Representative.

AMERICAN GAS ASSOCIATION

420 LEXINGTON AVENUE, NEW YORK 17, NEW YORK



FINKL forgings...



... and the MEN who make them

Meet Al, Don, Roy, Tony, Jack, Jim . . . Finkl press smith crews that make quality forgings and die blocks. Here, working with a 78,000 pound ingot of special analysis steel from Finkl's melt shop, these experienced men combine their skill and pride of workmanship to produce forgings and die blocks which prove that the finest product is the least expensive to you in the long run.

For 74 YEARS, "Forgings by Finkl" has meant dependability and quality. For 74 YEARS we have zealously guarded that reputation. And now, with complete control of quality from the analysis of the steel in our own melt shop through to the finished product, we can honestly say that Finkl forgings and die blocks are the finest available at the lowest cost to you.

MANUFACTURERS OF THE LARGEST FORGINGS IN THE MIDDLE WEST

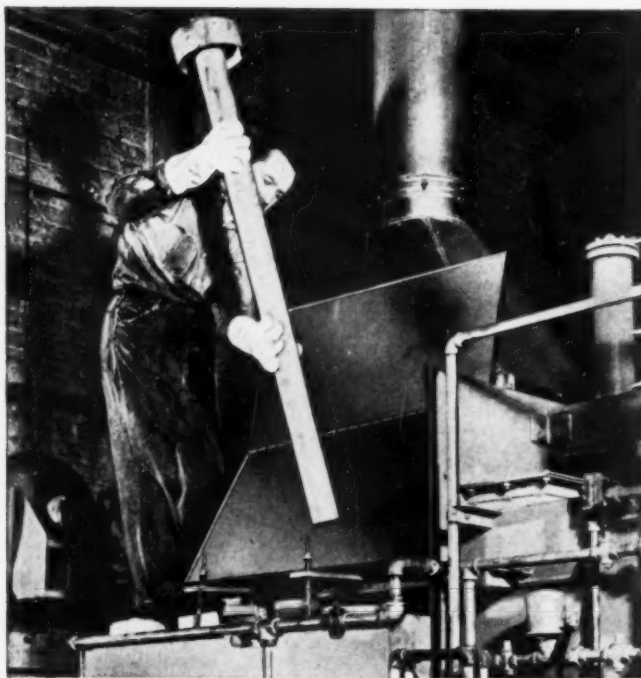


A. Finkl & Sons Co.

2011 SOUTHPORT AVENUE • CHICAGO 14

ELECTRIC FURNACE STEELS • DIE BLOCKS • FORGINGS

Inconel radiant tubes in new Lindberg multi-purpose furnace come out on top!



Time for a Change? It's no job at all to slip one of these thin-wall Inconel vertical tubes into the new Lindberg Carbonitriding Furnace. The tube collar, which forms a heat seal, is shaped from Inconel sheet and welded to the tube. These lightweight tubes transfer heat efficiently, yet give long service life because of Inconel's resistance to oxidation and many corrosive atmospheres at high temperatures.

You would hardly believe that replacing a radiant tube could be this simple — *but it is!*

In the carbonitriding furnace recently developed by the *Lindberg Engineering Company*, of Chicago, all you do is lift out the old tube and hang a new one in its place.

Inconel® tubes like the one shown above weigh only 29 pounds.

Yet they are sturdy and long-lasting. They resist oxidation and many corrosive furnace atmospheres at high temperatures. They must, for tubes really get a workout in this furnace! Lindberg designed it to handle not only carbonitriding, but hardening, carburizing, annealing and carbon restoration as well. Different furnace atmospheres are supplied by an adjustable generator.

Inconel takes all of these varying conditions in stride. It resists cracked ammonia and carbon monoxide atmospheres, and provides excellent strength throughout the entire carbonitriding temperature range. Its good strength persists at temperatures up to 2,200° F. Also, it is readily workable and can be welded by ordinary shop methods.

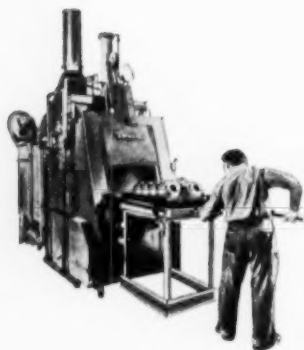
You can see, then, why Lindberg has standardized on Inconel tubes for their new furnace.

To learn how Inconel can serve you in troublesome high-temperature applications, write for a copy of the booklet, *Keep Operating Costs Down . . . When Temperatures Go Up*. It's yours on request.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.



Inconel...for long life at high temperatures



MIDGET



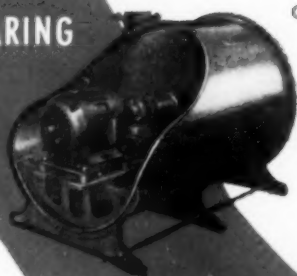
With universal motor, 35 to 75 cfm at 12 to 40 oz. pressure

GAS BOOSTER



For handling gas, acid fumes, poisonous, corrosive or explosive gases

4 BEARING



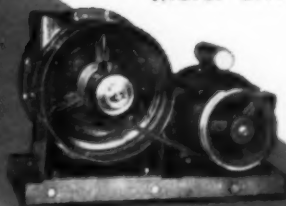
Overhang or outboard type for coupled drive



AIR FILTERS

Of various types for intake of Turbo

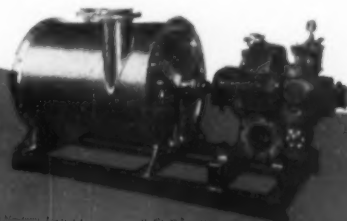
BELT DRIVE



For odd frequency or other than electric motor driven

For use where it is desired to operate with steam

TURBINE DRIVEN



SINGER NO. 76

440-F

SPENCER

HARTFORD

TURBOS



FOR SPECIAL OCCASIONS

Standard motor driven Spencer Turbos are listed in more than 160 sizes. For special applications, there are many variations, six of which are illustrated.

Spencer Turbos range in size from 35 to 20,000 cu. ft. per min. 4 oz. to 10 lbs. and 1/3 to 1,000 h.p.

For complete description of the standard and special Turbos ask for Bulletin No. 126-A.

THE SPENCER TURBINE COMPANY • HARTFORD 6, CONNECTICUT

SPENCER

HARTFORD

"YOUR COST PER FINISHED ARTICLE IS THE TRUE COST OF YOUR CLEANER"



The case of the "SPOTTED BUMPERS"



Gloom had settled over the "Super's" office. Inspection was rejecting bumper after bumper because of tiny defects marring its gleaming finish.

To make matters worse—ALL the usual test methods failed to disclose the cause of the rejects.

Finally — Northwest was called. A "Cleaning Specialist" rushed to the scene. His methodical check of the cleaning and plating operations revealed nothing amiss.

Retracing his steps, the Northwest "Cleaning Specialist" found "HER". A cute blond—busily racking bumpers—with lovely hands encased in gloves held together with liberal strips of zinc oxide tape.

Here was the culprit. Her taped gloves left invisible traces of rubber-like adhesive on the parts after they had been cleaned. A new pair of gloves and production returned to normal.

This little episode illustrates our point that Northwest's "Cleaning Specialists" are not only cleaning experts in a technical sense, but practical production engineers as well.

Any one can give you a cleaning compound that will do a job of sorts, but a Northwest "Cleaning Specialist" will give you the right cleaner to keep your line running smoothly. This is the reason so many plants rely on Northwest Chemicals AND SERVICE.



Got a problem?
Let our cleaning
experts help you!



NORTHWEST CHEMICAL CO.

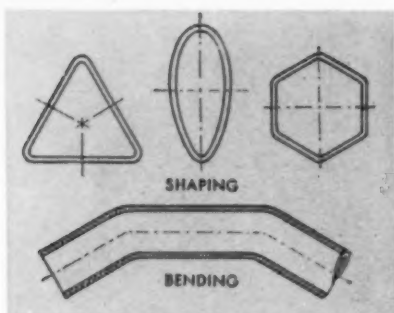
9310 ROSELAWN

DETROIT 4, MICH.

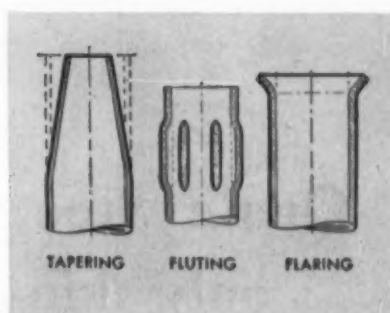
pioneers in pH cleaning control

serving you since '32

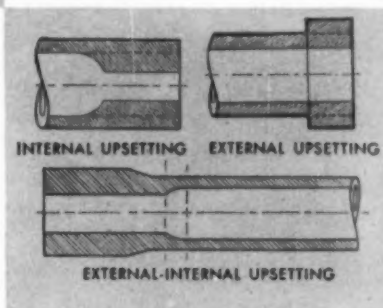




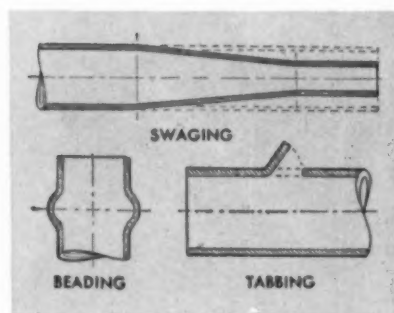
OSTUCO
TUBING
is versatile!



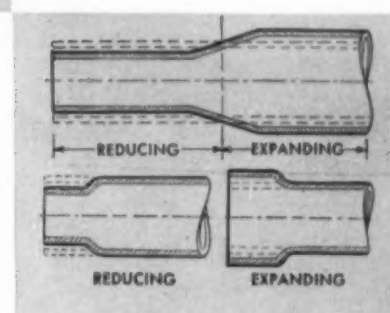
OSTUCO
TUBING
is versatile!



OSTUCO
TUBING
is versatile!



OSTUCO
TUBING
is versatile!



you draw the blueprint...we'll deliver the goods

There's practically no limit to the things OSTUCO can do with Seamless and Electric Welded Steel Tubing to help you produce lighter, stronger, better looking products at lower cost. Only a few of the operations are shown above.

Newly expanded and modernized facilities for *manufacturing, forging, and fabricating* tubing, all in one plant—plus our own steel source as a member of the Copperweld family

—speed deliveries, assure highest quality and save you money.

Tubing is our business, not a side line. OSTUCO's unique "Single Source" operation, with unified production control, eliminates shipments from one location to another . . . greatly reduces rejects . . . prevents errors . . . puts an end to buck passing and red tape. You write one order, get one bill, and responsibility is clearly fixed. Write for informative catalog, "Ostuco Tubing."

**OHIO SEAMLESS TUBE DIVISION
of Copperweld Steel Company**

Manufacturers and Fabricators of Seamless and Electric Welded Steel Tubing
Plant and General Offices: SHELBY, OHIO

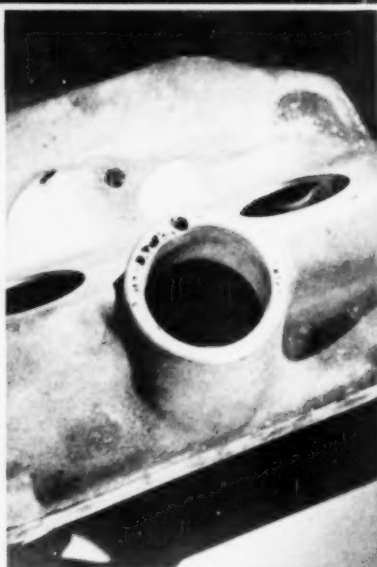


SALES OFFICES: Birmingham, P. O. Box 2021 • Chicago, Civic Opera Bldg., 20 N. Wacker Dr. • Cleveland, 1328 Citizens Bldg. • Dayton, 511 Salem Ave. • Detroit, 520 W. Eight Mile Road, Ferndale • Houston, P. O. Box 17007 • Los Angeles, Suite 300-170 So. Beverly Drive, Beverly Hills • Moline, 617 15th St. • New York, 70 East 45th St. • Philadelphia, 2004 Packard Bldg., 15th & Chestnut • Pittsburgh, 1206 Pinewood Drive • St. Louis, 1230 North Main St. • Seattle, 3104 Smith Tower • Syracuse, 2350 Bellevue Ave. • Tulsa, 245 Kennedy Bldg. • Wichita, 622 E. Third St. • Canadian Representative: Railway & Power Corp., Ltd.

Quality, too, may be only skin-deep



1 This apparently sound casting comes from the foundry ready for subsequent machining.



2 Machining uncovers blowholes at critical point — necessitating rejection or repair.



3 Radiograph made before machining would have revealed blowholes, saved time and money.

For fast, non-destructive inspection, use General Electric Industrial X-Ray

Whether you're buying or selling castings, x-ray inspection is a high-speed, low-cost method of insuring unvarying quality. Hidden defects in job lots or on production lines are detected prior to expensive finishing operations.

The above illustrations show why so many leading industries today rely on x-ray for non-destructive inspection. In many plants, x-ray is also used as a development tool — to disclose where savings can be

made, designs improved, new techniques developed.

Chances are, there's a place for industrial x-ray in your business. We will be glad to appraise your needs. Or, if you have a specific problem, GE has probably handled a parallel situation. You can benefit from this previous experience by writing X-Ray Department, General Electric Co., Milwaukee 1, Wis., Rm. AS-12.

You can put your confidence in —

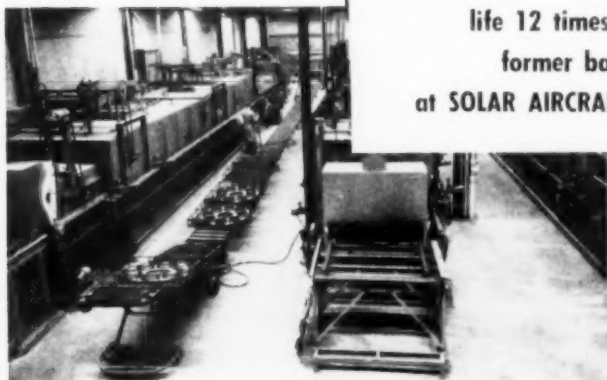
GENERAL  ELECTRIC

ROLOCK

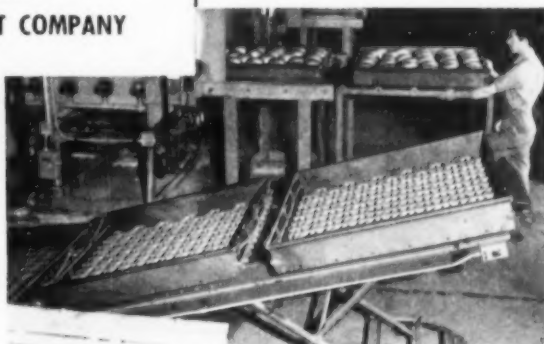
FABRICATED ALLOYS

HEAT AND CORROSION
RESISTANT

ROLOCK "Serpentine" basket
life 12 times that of
former baskets
at SOLAR AIRCRAFT COMPANY



Jet burner plates leaving gravity belt for travel thru furnace.



Baskets ready for loading, others entering furnace.

Baskets that carry jet engine parts thru these 73½-foot gas atmosphere furnaces for continuous annealing must withstand the tough maximum temperature of 2150° F. That calls for skillful designing of baskets and use of high heat resistant material. Rolock supplied Incoloy baskets incorporating their exclusive "Serpentine" base design, with rolled sheet on two sides and sturdy round rod on the other two... all superimposed and integral with the "Serpentine" fully articulated bottom.

Baskets are 42" x 42" x 6" deep O.D....weight 120 lbs., carrying a load of 200-250 lbs. As a replacement for baskets formerly used at Solar's Wakonda plant at Des Moines the new ones have, so far, given 12 times the service life.

Rolock engineers provide practical solutions of your container problem for heat treating or corrosion resistant processing... or will cooperate with your own departments for lower hour-cost designs and methods. We like tough problems... and welcome yours. Send them in!

CATALOGS ON REQUEST


Offices in: PHILADELPHIA, CLEVELAND, DETROIT, HOUSTON, CHICAGO, ST. LOUIS, LOS ANGELES, MINNEAPOLIS, PITTSBURGH

ROLOCK INC. • 1222 KINGS HIGHWAY, FAIRFIELD, CONN.

JOB-ENGINEERED for better work
Easier Operation, Lower Cost

ROL 518

How many SPARKS in a Spark Plug?

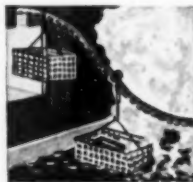


Surprising, the confidence that people have in spark plugs. No one stops to question how many "sparks" they're good for, because long-life performance has come to be taken for granted. Yet, when you get right down to it, you'll find good reasons for this complete consumer confidence. And, from a "sparking" point of view, perhaps the most important is the almost universal use of special Hoskins alloys for the vital electrode wires.

Producing the wire that sparks your car to power is a tough and tricky business. It requires special care in the selection of raw materials. Special melting and production techniques. Plus extremely close control over alloy composition and uniformity of quality throughout the entire manufacturing process.

Yet that's exactly the kind of alloy that Hoskins is qualified to produce best. For, among the other quality-controlled alloys developed and manufac-

tured by Hoskins are: Alloy 717—for facing engine valves; Alloy 785—for brazing belts; Alloy 502—for countless heat resistant mechanical applications. Then, too, there are the Chromel-Alumel thermocouple alloys . . . guaranteed to register true temperature-EMF values within specified close limits. And, of course, Hoskins CHROMEL . . . the *original* nickel-chromium resistance alloy used as heating elements and cold resistors in countless different products.



Hot stuff for hot jobs! Hoskins Alloy 502 is ideally suited to many mechanical-structural applications.



Heating elements made of Hoskins Chromel deliver full-rated power throughout their long and useful life.



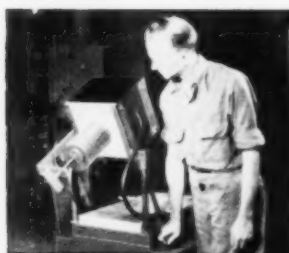
Chromel-Alumel thermocouple alloys accurately measure exhaust temperatures of jet aircraft engines.



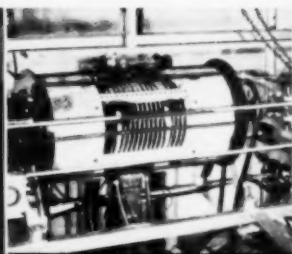
HOSKINS

MANUFACTURING COMPANY

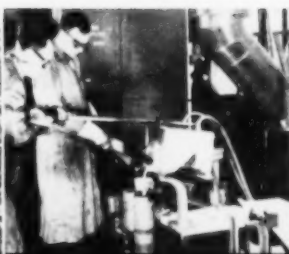
4445 LAWTON AVENUE, DETROIT 8, MICHIGAN



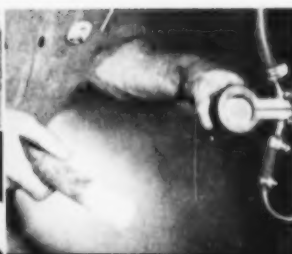
PRECISION CASTING



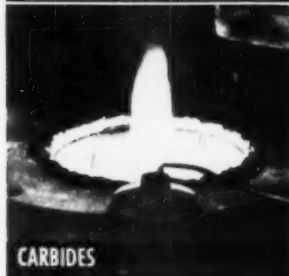
HOT PRESSING



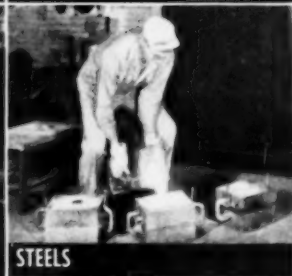
BRONZES



HEAT TREATMENT



CARBIDES



STEELS



SHELL MOLDING



PRECIOUS METALS

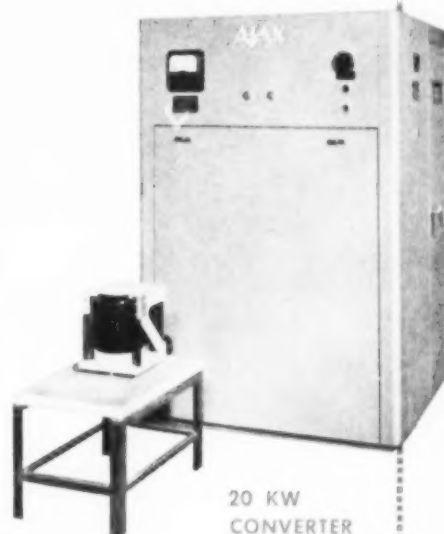
"In Production" — with Minimum Investment

AJAX-NORTHROP Converter-Operated FURNACES

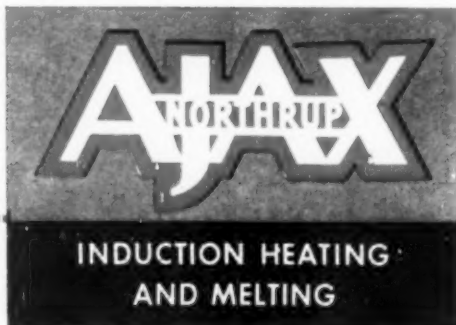
The 20 kw. converter will melt 17 pounds of steel in 40 minutes. Maximum capacity is 30 pounds of steel or 60 pounds of bronze. The larger 40 kw. unit melts faster, will handle up to 50 pounds of steel. The 6 kw. unit melts a pound of steel in 8 minutes. Controlled temperatures to 4500 deg. F and higher make these furnaces ideal for sintering and hot pressing carbides.

Ajax-Northrup converters are compact and self resonating. They require no special foundation or wiring—and they're certified to meet F. C. C. regulations.

Thousands of these units are in daily use. Many of today's prominent industries actually got their start with an Ajax-Northrup 20 kw. converter. Write for bulletins.



20 KW
CONVERTER

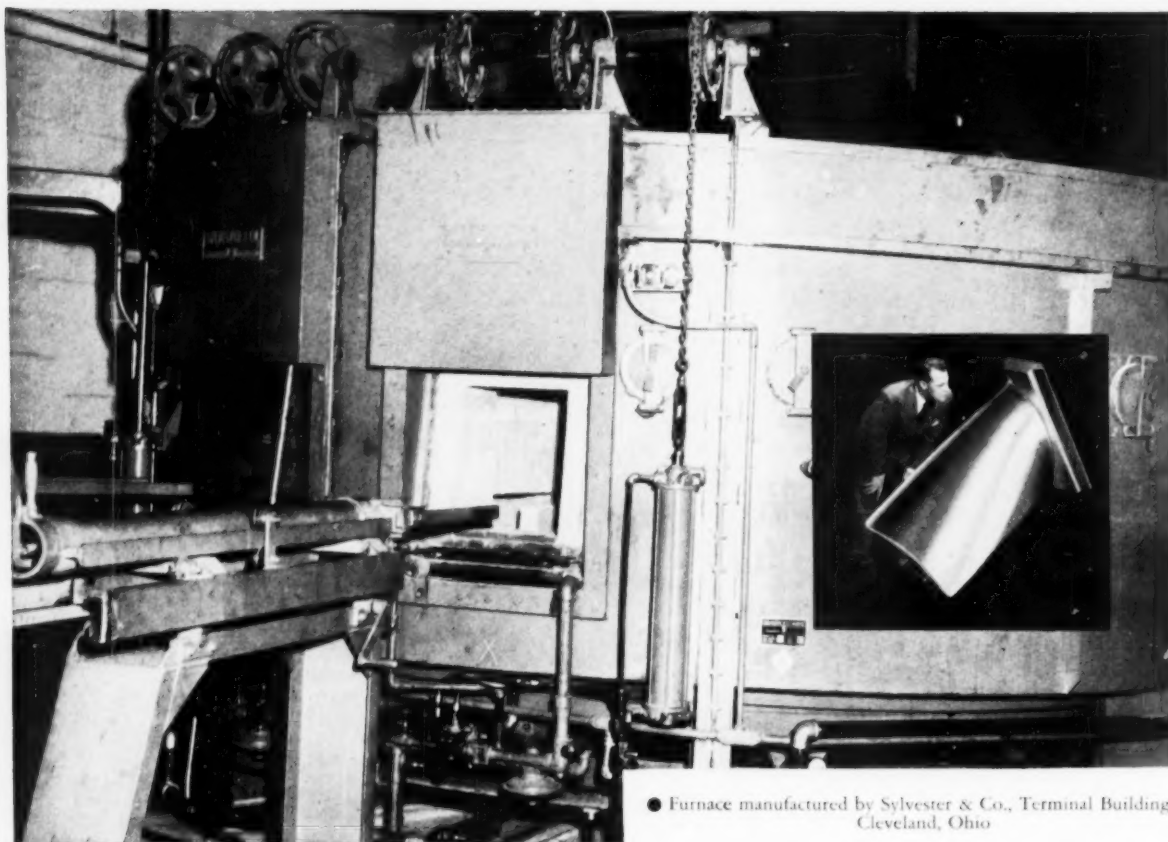


Since 1916

AJAX ELECTROTHERMIC CORPORATION
Ajax Park, Trenton 5, New Jersey

Associated Companies

AJAX ELECTROMETALLURGICAL CORP.
AJAX ELECTRIC FURNACE CORPORATION
AJAX ELECTRIC COMPANY, INC.
AJAX ENGINEERING CORPORATION



● Furnace manufactured by Sylvester & Co., Terminal Building, Cleveland, Ohio

How GLOBAR® Heating Elements can cut your heat treating costs

Look at the ways you reduce rejects and production costs with a modern electric heat treating furnace equipped with GLOBAR® Brand silicon carbide heating elements.

For instance, this Sylvester rotary hearth furnace equipped with forty-eight GLOBAR non-metallic heating elements, is lowering production costs on jet engine turbine blades. This single 250 KW unit can heat 1200 lbs. of steel per hour to 2150°F.

Because loss of metal as scale can often be eliminated by using a protective atmosphere, parts to be hardened are usually machined to exact dimensions... and cleaning after soaking is unnecessary, in many cases.

Get these advantages of furnaces using GLOBAR heating elements: pickling and acid disposal eliminated—permitting equipment to be located right in the production area; higher thermal efficiency—which cuts fuel costs; automatic controls—which lower labor costs; fuel handling and processing eliminated, as well as the added cost of furnace construction needed to burn other fuels.

Let us show you how GLOBAR heating elements can best serve you in heat treating—or any other industrial furnace operation. Write today to The Carborundum Company, Dept. MP 87-310, Niagara Falls, N. Y.

GLOBAR® Heating Elements give you

- 1 **MORE HEAT...** per unit area of hearth.
- 2 **WIDEST RANGE OF TEMPERATURES...** up to 2750°F.
- 3 **SIMPLICITY** of furnace construction.
- 4 **LESS DOWNTIME...** no need to cool or unload during replacement.



GLOBAR®
Heating Elements
by **CARBORUNDUM**
REGISTERED TRADE MARK

How to get maximum tube life per dollar: Ask the experts!

This month's report is on:

SICROMO 7

Suggested as a substitute for steels of the 5.0 per cent chromium type for applications which require increased resistance to corrosion by hot petroleum products.

ONE OF 24 TIMKEN HIGH TEMPERATURE STEELS

Carbon	Sicromo 2	Sicromo 5S	18-8 Ti
Carbon-Mo.	Sicromo 2½	Sicromo 5MS	16-13-3
DM-2	2¼% Cr.-1% Mo.	Sicromo 7	25-20*
Silmo	Sicromo 3	Sicromo 9M	25-12*
DM	4-6% Cr.-Mo.	18-8 Stainless	35-15**
2% Cr.-Mo.	4-6% Cr.-Mo.-Ti.	18-8 Cb	16-25-6**

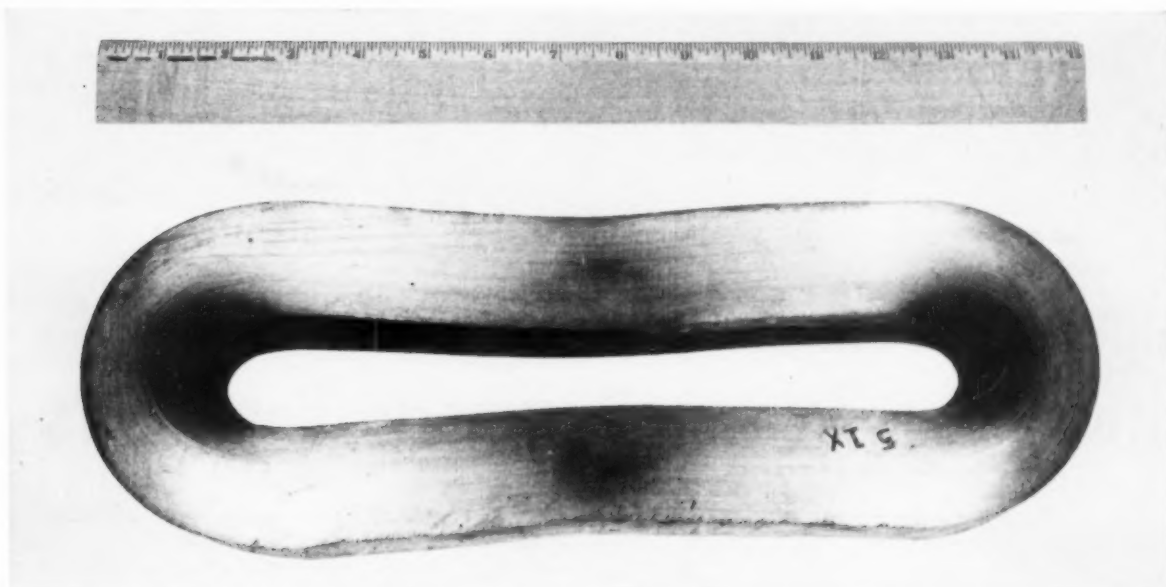
* Available as seamless tubing on an experimental basis only.

**Not available as seamless tubing.

YOUR temperature, pressure, corrosion and oxidation problems may be solved by several analyses of high temperature steels. But from the standpoint of maximum tube life per dollar—the best life/cost ratio—there's only one analysis that's best for you.

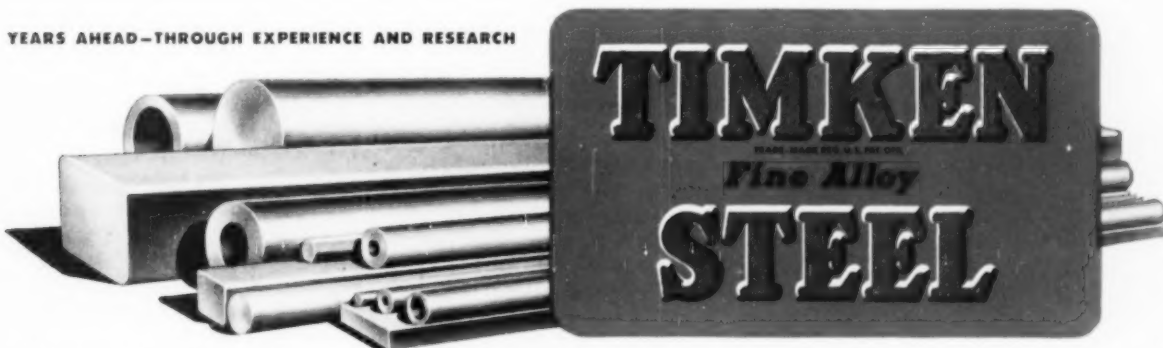
To get that one analysis, go to metallurgists of The Timken Roller Bearing Company. They're recognized authorities on high temperature steels—with more than 20 years of steel research and experience behind them. They'll help you choose the one tube steel analysis that's best for your application from the 24 different analyses at their disposal. And no matter which one you choose, you can be assured of uniform quality because the Timken Company rigidly controls quality from melt shop through final tube inspection.

Let our "RSQ"—Research, Supply, Quality—solve your tube problems. *Ask the experts!* The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

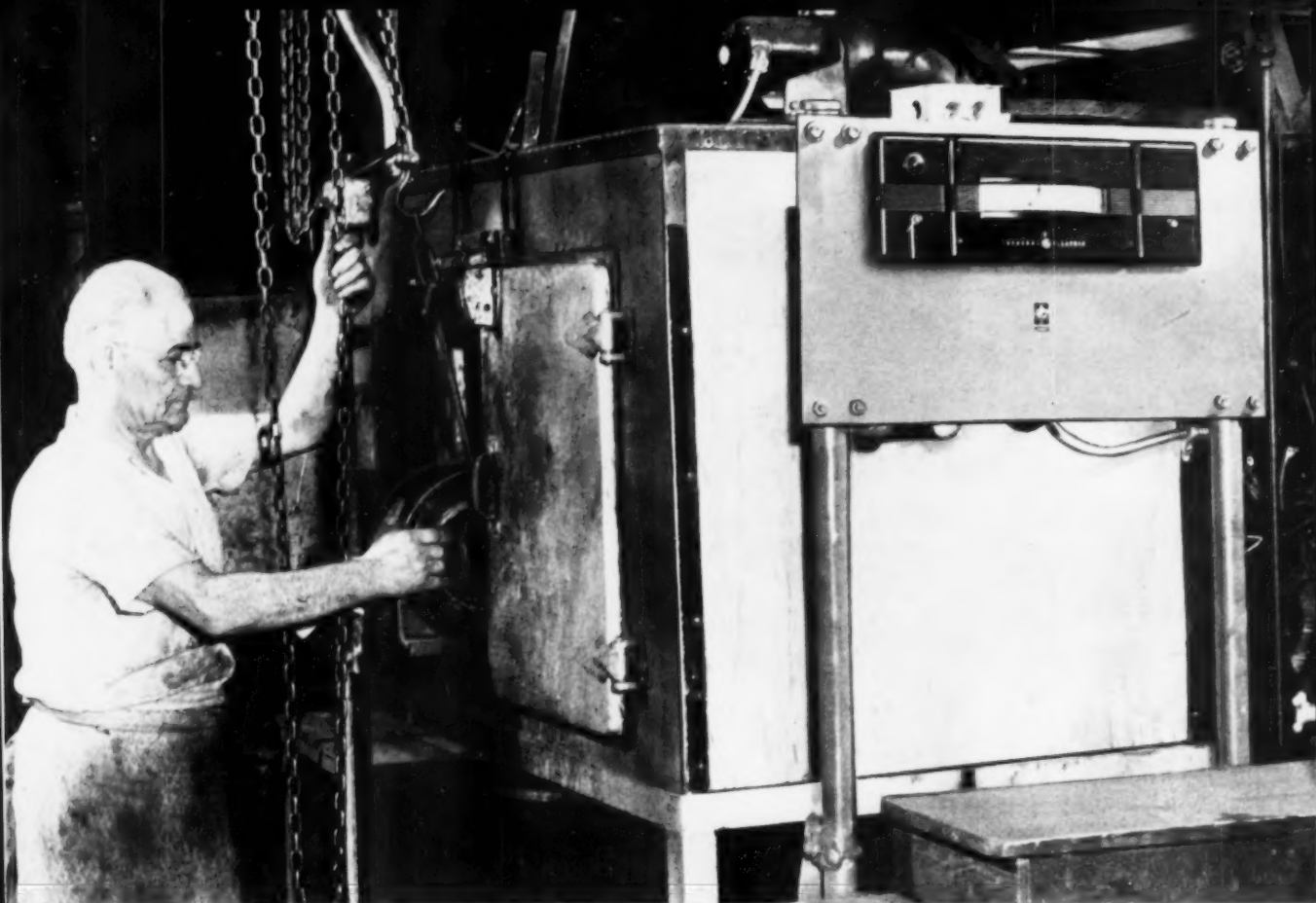


Flattened test of 10½" O.D. by 1.580" wall of 18-8 Cb showing the excellent ductility of large, heavy-wall Timken seamless tubing.

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH



SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING



G-E PYROMETER-CONTROLLER ASSURES EVEN TEMPERATURES IN BAKING OF MOTOR STATORS—HELPS REDUCE REJECTS

Improve Product Quality, Reduce Rejects with G-E Precision Pyrometer-Controllers

Excessive overheating costs you money—as production rejects increase and your product's quality drops.

General Electric pyrometer-controllers offer you a low-cost way (prices start at \$215.78*) of maintaining even furnace temperatures despite changes in voltage or ambient. This precision control can help you to reduce rejects, and hold the line on product quality.

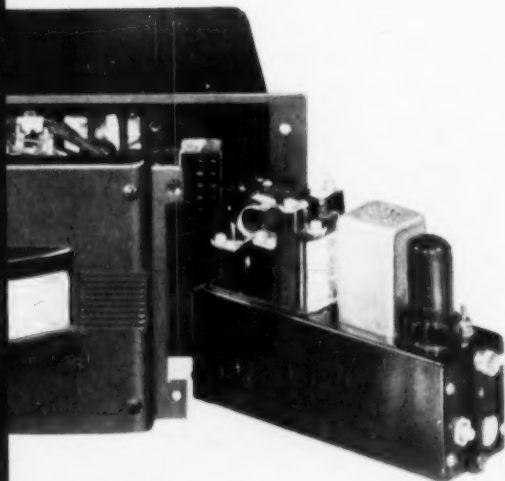
HIGH SENSITIVITY of G-E controllers means that any change in temperature equal to $\frac{2}{10}$ of 1% of full scale is enough to initiate control action.

This line of HP controllers is accurate to $\frac{3}{4}$ of 1% of full scale.

SEVERAL TYPES AVAILABLE, including indicators, indicator controllers, and protectors—in either 2-position or 3-position models. Scale requirements can be fulfilled from a variety of ranges in the 0-3000F span.

FOR COMPLETE INFORMATION, contact your G-E Apparatus Sales Office, or write for Bulletin GEC-713 to General Electric Company, Schenectady 5, N. Y. 602-264

*Manufacturer's suggested retail price.



PLUG-IN CONTROLLER UNIT pulls out easily for convenient maintenance checking. Standard vacuum tube may be replaced at low cost at any radio-tube supply store.

GENERAL  **ELECTRIC**

WHAT'S YOUR ALLOY STEEL PROBLEM?

**SELECTION?
STRENGTH?
HARDNESS?
TOUGHNESS?
MACHINABILITY?
HEAT TREATMENT?
TOOL LIFE?
SURFACE FINISH?
LOW PRODUCTION?
HIGH UNIT COSTS?**

Check your problem . . . or problems. Then call in Republic's 3-Dimension Metallurgical Service.

The man you meet will be the Republic Field Metallurgist. He comes to your plant, studies your product, examines your production methods. His report goes back to the Republic Mill and Laboratory Metallurgists.

These three specialists then work together to diagnose the trouble. From their wide knowledge of alloy steels, how they respond to forging, to heat treatment, to any work or process, they make recommendations. Not general ones, but those suitable for your plant and your particular problems, based on efficiency. And they stay within, or below, your cost limits. The results? Higher quality, greater output, economy.

Scores of Republic customers already have attained these benefits by taking advantage of this service. Ask your Republic salesman to call in his 3-Dimension Metallurgical Service. It's yours for the asking.



...combines the extensive experience and coordinated abilities of Republic's *Field, Mill* and *Laboratory* Metallurgists with the knowledge and skills of your own engineers. It has helped guide users of Alloy Steels in countless industries to the correct steel and its most efficient usage. IT CAN DO THE SAME FOR YOU.

REPUBLIC STEEL CORPORATION

Alloy Steel Division • Massillon, Ohio

GENERAL OFFICES • CLEVELAND 1, OHIO

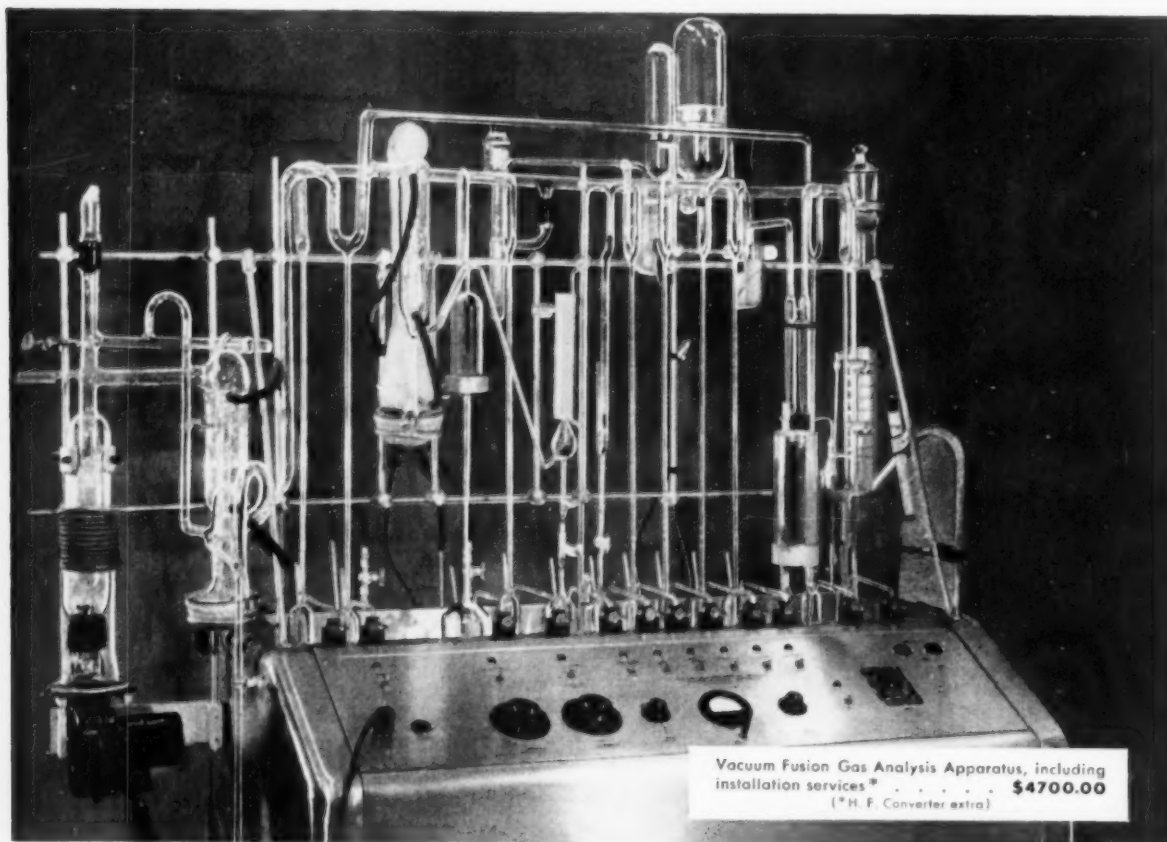
Export Department: Chrysler Building, New York 17, N.Y.



Other Republic Products include Carbon and Stainless Steels—Sheets, Strip, Plates, Pipe, Bars, Wire, Pig Iron, Bolts and Nuts, Tubing

Vacuum Fusion Gas Analyzer

with complete installation and instruction



Vacuum Fusion Gas Analysis Apparatus, including installation services* \$4700.00
(*H. F. Converter extra)

A packaged unit to determine the content of oxygen, nitrogen and hydrogen in metals

A wide variety of metals and alloys can be analyzed to determine the amount of oxygen, nitrogen and hydrogen contained either as combined or dissolved gas, in the range from one per cent to approximately 10^{-4} per cent by weight.

The oxygen and hydrogen content of titanium is reported within the same range of accuracy as for other metals.

The apparatus incorporates the best features and techniques reported in the literature or known to our laboratory and has been employed for some time in connection with our own metallurgical research activities.

Operating procedure is relatively simple and can be readily mastered. Installation, final testing and instruction of your operator is performed by one of our trained analysts.

Write for details of Type 09-1240 Vacuum Fusion Gas Analysis Apparatus.

ANALYTICAL SERVICE

Write for information about NRC Gas Analysis Service if your requirements do not justify the purchase of an instrument.

INDUSTRIAL RESEARCH

CHEMISTRY, METALLURGY
HIGH VACUUM ENGINEERING



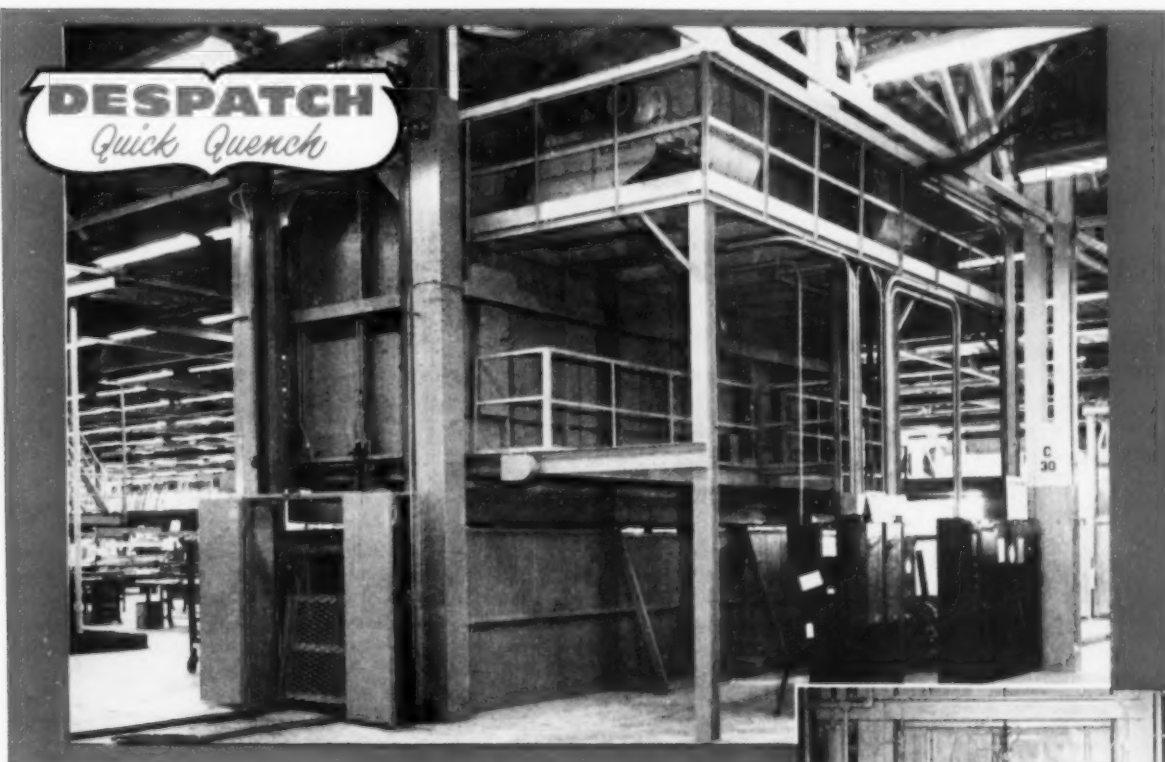
PROCESS DEVELOPMENT

PHYSICS, DEHYDRATION
DISTILLATION, VACUUM COATING

National Research Corporation

EQUIPMENT DIVISION

SEVENTY MEMORIAL DRIVE, CAMBRIDGE 42, MASSACHUSETTS

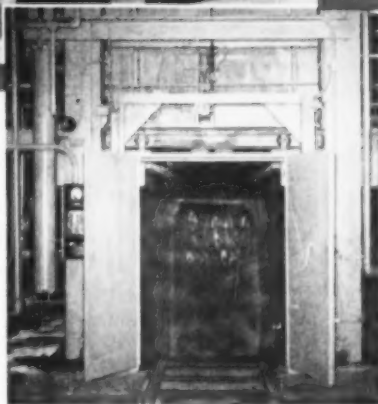


THE FURNACE OF PROVEN SPEED AND DEPENDABILITY IN THE SOLUTION HEAT TREATING OF ALUMINUM!

EIGHT SECONDS OR LESS is all the time required from heat chamber to complete quench with this DESPATCH high production aluminum heat treating furnace now operating in the aircraft division of a large automotive firm.

910° F. IN 25 MINUTES: A 426 KW heater has sufficient capacity to raise a 950# aluminum work load plus a 1000# steel rack to 910° F. in 25 minutes. Two high volume recirculating fans of 25,000 CFM each deliver heated air to the furnace, and heat uniformity is assured within a $\pm 5^\circ$ F. Furnace is designed to operate up to 1250° F. when desired.

ELEVATORS AND WORK CHAMBER DOORS are hydraulically operated and interlocked with push button controls providing automatic sequence operation thru the complete cycle from heat treating to quench to unload. Furnace takes a work rack 4' wide, 5' high and 22' long.



EFFICIENT FOG QUENCH PREVENTS WARPAGE

An intermediate fog quench at floor level is provided before load is immersed in recessed tank. A series of fog jet nozzles are so arranged as to cover the load completely with a dense fog, a precaution against warpage of certain aluminum parts. The fog quench may be by passed if desired.

DESPATCH
Engineers, Fabricates and
Installs a Complete Line of—

- ★ INDUSTRIAL FURNACES
- ★ INDUSTRIAL OVENS
- ★ HEATERS AND FANS
- ★ PAINT SPRAY BOOTHS
- ★ COMPLETE FINISHING SYSTEMS

PLAN FOR THE FUTURE WITH DESPATCH

DESPATCH ENGINEERS are designing heat treating equipment today with tomorrow's higher production demands in mind. When planning for the future in your plant

it will pay you to keep DESPATCH in mind because DESPATCH equipment is tailored to your particular needs to give you the most efficient operation at lowest costs.

Write, wire or call Dept. P



MINNEAPOLIS OFFICE: 419 S. 5TH ST. • CHICAGO OFFICE: 4854 N. Broadway
Sales Offices in all Principal Cities

PIONEERS IN ENGINEERING HEAT APPLICATIONS FOR INDUSTRY

Announcing

NICKEL-LUME

A NEW BRIGHT NICKEL PROCESS BY HANSON-VAN WINKLE-MUNNING COMPANY

H-VW-M takes great pleasure in presenting Nickel-Lume, a superior new bright-nickel electroplating process. Nickel-Lume addition agents are of the organic type, yet have none of the inherent faults and limitations of previous organic agents. A result of several years of careful research and development, Nickel-Lume has been subjected to stringent field tests both in job shops, with a wide variety of work and plating problems, as well as in large plant production using full-automatic equipment. In every test, Nickel-Lume has shown excellent results, a really bright finish directly from the plating bath with all these marked advantages:

OUTSTANDING BRIGHTNESS—full, bright deposits over a wide range of operating conditions. Relatively thin deposits, too, are *really bright*; lustre builds as thickness increases. Even intricate, deeply-recessed articles have uniform brightness without shading.

LOW INTERNAL STRESS—stress can be controlled to a low value on either the compressive or tensile side and held within satisfactory limits as the solution ages—no cracking, crazing, lifting, or brittleness of deposits.

HIGH DUCTILITY—comparative nickel tests show surprising ductility—even after continued bath use in production.

GOOD LEVELING—in normal deposits surface roughness is reduced 50% more. Costly polishing and buffing can be substantially reduced.

WIDE CURRENT DENSITY RANGE—without noticeable change in brightness, current density can vary from below 5 to above 70 asf. Plating speeds can change to meet various production schedules and specifications.

WIDE SOLUTION TEMPERATURE RANGE—baths may be operated at room temperature with full deposit brightness up to and beyond 140°F. With moderate to high current densities, a temperature above 120°F. is seldom required.

GOOD STABILITY—no breakdown of addition agent, therefore no cloudy, brittle, or highly-stressed deposits. No time-consuming, costly "stripping" operations.

HIGH TOLERANCE TO IMPURITIES—no bath "upset" by a few milligrams of metallic or organic impurities. As a rule, organics are tolerated in greater concentrations than in other bright baths.

SUPERIOR THROWING POWER—equal to or better than other commercial processes. Deposits—even in recessed areas—have uniform brightness without shading.

GOOD CORROSION PROTECTION QUALITIES—addition agent nature plus constant deposit characteristics give a high level of protection to the plated surface.

SIMPLE CONTROL—all constituents, including addition agents, can be determined and controlled by chemical analysis, thus maintaining deposits at constant and optimum characteristics.

PLEASING WHITE COLOR—approaching well-known cobalt-nickel deposits in whiteness of color—not the unappealing, yellow cast usually associated with organic addition agents.

NO OBJECTIONABLE FUMES—ventilation is *not required*—bath temperature is low, and no obnoxious or dangerous fumes are given off.

HIGH DEPOSIT ACTIVITY—deposit surfaces are exceedingly active and accept chromium or other deposits without activating treatment. In some installations, work with defective surfaces goes right back through normal plating cycle without blistering of nickel-on-nickel.

LOW INSTALLATION COSTS—all that is needed is equipment for a Watts nickel bath. Filtration can be periodic or continuous. No ventilation is required. Heat demands are low. Existing auxiliary equipment can be used.

LOW OPERATING COSTS—initial cost comparable to other bright nickel baths *but*, cost of brightener replenishment is much lower. Control is simple. No frequent pumping out and bath treatment. No production loss through sudden failure of bath to perform satisfactorily. Regular non-premium anodes are used.

Complete details and instruction manual will be forwarded on request.



Your H-VW-M combination—of the most modern testing and developing laboratory—of over 80 years experience in every phase of plating and polishing—of a complete equipment, process and supply line for every need.

HANSON-VAN WINKLE-MUNNING CO., MATAWAN, N. J.
PLANTS AT: MATAWAN, N. J. • ANDERSON, INDIANA
SALES OFFICES: ANDERSON • BALTIMORE • BOSTON
CHICAGO • CLEVELAND • DAYTON • DETROIT • GRAND
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ROCHESTER • SPRINGFIELD (MASS.) • STRATFORD (CONN.)
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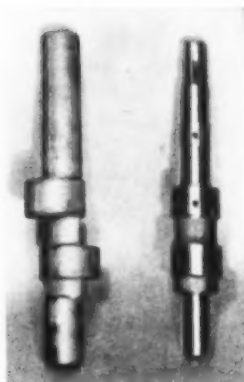


H-VW-M

INDUSTRY'S WORKSHOP FOR THE FINEST IN PLATING AND POLISHING PROCESSES • EQUIPMENT • SUPPLIES



This furnace helps make ice cubes and cool breezes



TWO Detroit Rocking Electric Furnaces produce the iron alloys for castings used by York Corporation in their ice-making and air conditioning equipment. The furnace illustrated has an 8000 lb. capacity; the other's capacity is 2000 lbs.

In the York foundry, Detroit Rocking Electric Furnaces were chosen to meet the requirements for high quality

Raw casting and finished crankshaft of York hermetic compressor. Cast from metal melted in Detroit furnace.

heats produced with speed and economy. Rocking action of the furnaces makes full use of heat from the indirect arc, and guarantees a homogeneous melt. Better metal means better castings, fewer rejects, lower cost.

Investigate Detroit Rocking Electric Furnaces for your needs. For ferrous and nonferrous metals. Capacities from 10 to 8000 lbs. Each installation is engineered to fit *your* particular requirement, solve *your* problem.

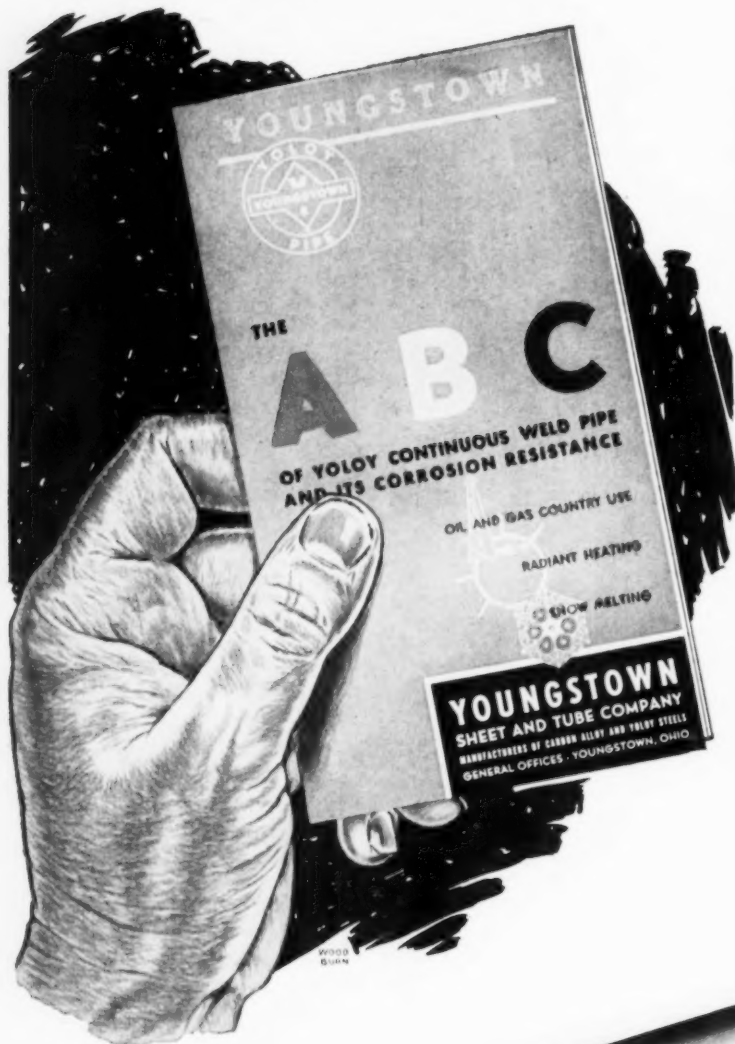
DETROIT ELECTRIC FURNACE DIVISION

KUHLMAN ELECTRIC COMPANY, BAY CITY, MICHIGAN

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This DATA may solve YOUR piping problem



● Here is the up-to-date story of Yоло Continuous Weld Pipe—a remarkable low alloy steel whose nickel-copper content gives it unique ability to withstand corrosion, abrasion and shock. These outstanding advantages combined with high strength, ductility and weldability make Yоло Pipe an excellent selection.

Proved by 18 years of satisfactory performance, Yоло is highly recommended by users in such service as radiant heating, snow melting, gas line gathering, brine lines and other industrial piping.

This new folder presents the facts and figures on Yоло's physical and chemical properties, with data on sizes now available and other information you'll need to select Yоло Continuous Weld Pipe to meet your special requirements. Write for a copy today.



THE YOUNGSTOWN SHEET AND TUBE COMPANY

Manufacturers of Carbon, Alloy and Yоло Steel

COLD FINISHED CARBON AND ALLOY BARS · ELECTROLYTIC TIN PLATE · COKE TIN PLATE · WIRE · PIPE AND TUBULAR PRODUCTS · CONDUIT · RODS · SHEETS · PLATES · BARS · RAILROAD TRACK SPIKES.

General Offices: — Youngstown 1, Ohio

Export Office: 500 Fifth Avenue, New York

Looking into the Blastmaster Barrel at Detroit Harvester. Abrasive-tight door has been opened for easy unloading. Note gleaming finish of cleaned pieces.



**PANGBORN
BLASTMASTER BARREL**

PANGBORN BLASTMASTER BARREL

Cuts Cleaning Time 56%

And gives "finest finish" to the work for Henry and Allen Division of Detroit Harvester Co., Auburn, N. Y.

Formerly, the cleaning operation at Detroit Harvester required 44½ hours a week. Now a Pangborn Blastmaster handles all blast cleaning requirements in only 20 hours a week! So cleaning time has been cut 56%. In addition, labor costs have been reduced and experienced men are released for other work. Superintendent F. C. Palmer reports, "We are highly pleased with the new Pangborn Barrel. It is very fast and thorough . . . saves money by cutting our blast cleaning job to less than half."

Quality? Here's what Assistant Foreman Mike Hulik (with the company since 1912) has to say: "This new Pangborn machine gives us the finest finish I have ever seen."

The Blastmaster at Detroit Harvester is not an unusual installation. Blastmasters all over the country are winning commendations for fast, cost-cutting, quality performance on ferrous, non-ferrous and other metal castings. If you are interested in better, cheaper cleaning, it will pay you to investigate the Pangborn Blastmaster Barrel. Available in 4 sizes—3, 6, 12, or 18 cu. ft. capacities. For more details, write for Bulletin 223 to: PANGBORN CORP., 1800 Pangborn Blvd., Hagerstown, Maryland.

102
Sold in
10 months

**OVER 28,000 PANGBORN MACHINES
SERVING INDUSTRY**

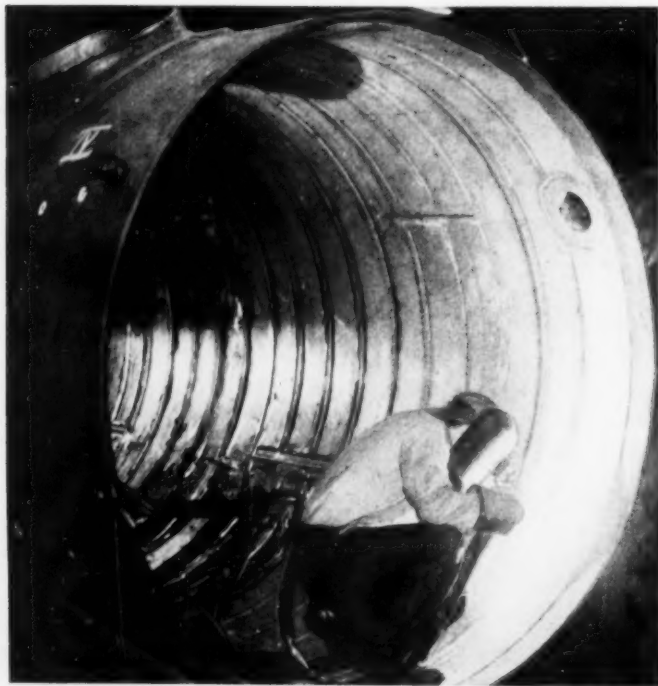
Pangborn

Look to Pangborn for the latest developments in Blast Cleaning and Dust Control equipment.

**BLAST CLEANS
CHEAPER**

with the right equipment for every job

Made to Last in Severe Corrosives



◀ A TOWER OF RESISTANCE

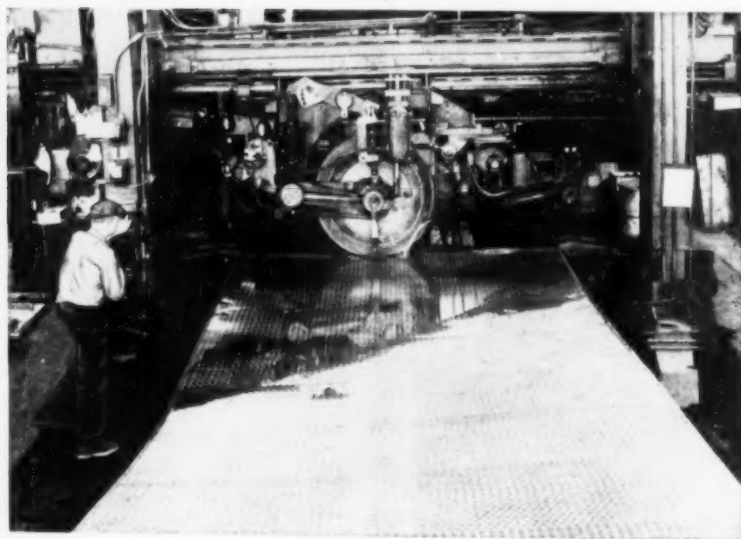
Strips of HASTELLOY alloy C are being arc-welded to this 44-ft. long tower to give it added corrosion resistance. The entire inside surface of the vessel is covered with $\frac{1}{8}$ -in. thick sheet.

SEALING OUT CORROSION

This lining of HASTELLOY alloy F will resist acids and alkalis. It is attached to steel by the Smithlining* spotweld process, one of the many ways of attaching HASTELLOY alloys to steel. Use of lined-sheet is an economical means of handling severe corrosives.

HASTELLOY alloys can help solve your corrosion problems, too. For further information, contact the nearest Haynes Stellite Company office.

*"Smithlining" distinguishes an exclusive process of the A. O. Smith Corporation, Milwaukee, Wisconsin.



HASTELLOY *alloys*

TRADE-MARK

Nickel-base, corrosion-resistant alloys available as sheet, plate, bar stock, welding rod, welded tubing and pipe, cast pipe and pipe fittings, sand and precision-investment castings.

"Hastelloy" is a registered trade-mark of Union Carbide and Carbon Corporation.

Haynes Stellite Company

**A Division of
Union Carbide and Carbon Corporation**

UCC

General Offices and Works, Kokomo, Indiana

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Sphero-Conical
DIAMOND BRALE^{*} PENETRATOR
for Hardened Steel

HOW IT WORKS

- A. Minor Load Penetration
- B. Major Load Penetration
- C. Linear measurement of penetration increase which "ROCKWELL[®]" converts to hardness reading



***BRALE Penetrator Accuracy Is Proved
in Wilson's Standardizing Laboratory***

● One point of hardness on the Rockwell C scale equals .00008" so penetrator accuracy must be constant. That's why Wilson maintains its Standardizing Laboratory for testing on many test blocks and approving every BRALE penetrator.

Each BRALE is precision ground to shape under high magnification and is accurate to the degree required for a research laboratory. Wilson's BRALE Penetrator gives true readings at all points on the dial. To get the greatest accuracy from your hardness tester, see that it is equipped with a diamond BRALE penetrator.

*Trade Mark Registered

ACCO

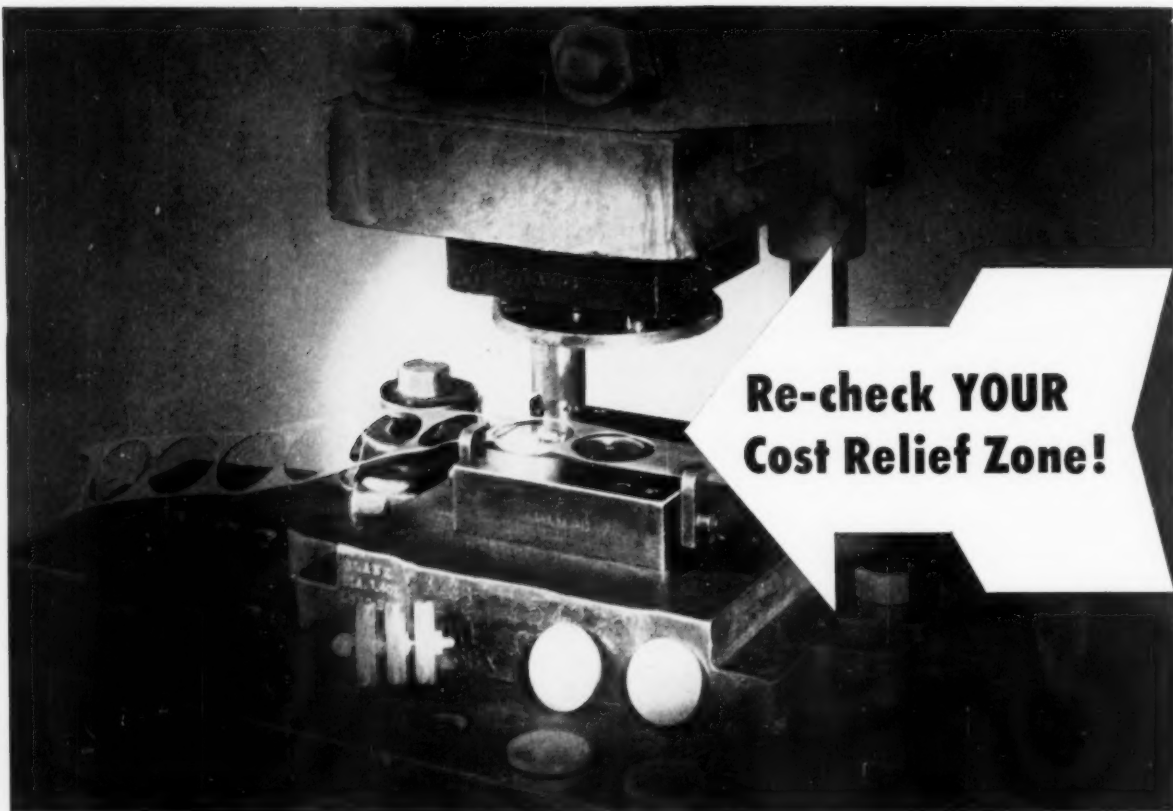


Write for literature

**WILSON MECHANICAL INSTRUMENT DIVISION
AMERICAN CHAIN & CABLE**

230-F Park Avenue, New York 17, N. Y.

**WILSON
"ROCKWELL"
and TUKON
Hardness
Testers**



**Re-check YOUR
Cost Relief Zone!**

**Here's a Challenging Opportunity for Every Man
Responsible for Tooling and Production**

Your *tools* and *dies* represent an immediate opportunity to bring unit costs down to a reasonable level. A quick re-check of this vital cost zone can result in definite savings. Sometimes these savings show up in less die finishing or adjusting. Or in longer runs with less downtime for regrinding. Many times they come about through a drastic reduction in the *number* of tools and dies you make each year.

Actual job records in plant after plant *prove* these cost economies can be realized. A good example is the job shown above. A re-check of these dies, used to blank and form .008" thick bronze thermostat diaphragms, showed that a different steel with better wearing qualities was needed to reduce excessive downtime for regrinding. This steel, Carpenter Hampden (Oil-Wear), eliminated 11 hours of machine downtime each week and produced over a half-million extra diaphragms per grind!

Certainly, if other plants are finding new output and production savings by re-checking their tools and dies, you can too. First step is to use The Carpenter Matched Set Method to select the one steel best suited for your job. By so doing, you back your selection with really dependable Carpenter Matched Tool and Die Steels. Then a call to your nearest Carpenter Mill-Branch Warehouse or Distributor brings fast delivery from stock. THE CARPENTER STEEL COMPANY, 133 W. BERN ST., READING, PA.

Are You Missing These Opportunities In Your Cost Relief Zone?



- Less die finishing and adjusting
- Greater output between grinds
- Fewer heat treating failures
- Less machine downtime

On Job After Job Carpenter Matched Tool and Die Steels Have Made Them Possible!



Carpenter

STEEL

Matched Tool and Die Steels

Export Department: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

Mill-Branch Warehouses and Distributors in Principal Cities Throughout the U. S. A. and Canada

It's Here!

Non-Corrosive Soldering Of
Any Type Aluminum Alloy



Aluma-Flux

SOLDERING FLUX

A UNIVERSAL FLUX FOR ALL
COMMERCIAL METALS USUALLY
JOINED BY SOLDERING

The success of S-X Aluma-Flux in the soldering of aluminum is due to the action in which the flux initially reduces surface oxides and then immediately deposits a thin layer of plating material on the solder area. Oxidation of the area to be soldered is thus prevented while the plating material serves as an approved base on which to solder. In addition to its soldering efficiency, Aluma-Flux reacts completely during the joining operation so there are no corrosive flux residues to lower corrosion resistance of the finished joint.

Manufactured By
ESSEX WIRE CORPORATION
St. Wayne, Ind.

HERE is the only flux ever made that assures the *non-corrosive joining* of every type of aluminum alloy regardless of soldering method—mechanical, manual or dip. No corrosive residue remains in most cases, and soldered pieces can be used immediately after the joining operation.

In addition to aluminum, use S-X Aluma-Flux for soldering stainless steel, nickel, brass, copper, bare or galvanized steel, cast iron, and other ferrous alloys. Use it for the quick and easy joining of unlike metals such as brass and aluminum, and for coating copper with tin. There is no other flux like it!

Even when exposed to salt spray, high humidity, alkaline water and other normal corrosion-inducing conditions, aluminum joints made with S-X Aluma-Flux produce no corrosive action. No type of detrimental effect on any soldered joint results from Aluma-Flux.

S-X Aluma-Flux is equally effective when used in molten form, or in powdered form as delivered, whichever is best for the job. Practically any type of solder can be used. And because Aluma-Flux is non-hygroscopic will not absorb water—it can be stored indefinitely without change of weight or fluxing efficiency.

Write For Test Sample & Details

Aluma-Flux Is Ready For Immediate Shipment In Convenient Size Metal Containers

Distributed Only By

INSULATION and WIRES incorporated

1534A Swinney Ave. • St. Wayne 5, Indiana

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CHASE WIRE
*can help keep
 your production
 costs down*

You cut down rejects when you use Chase Brass and Copper Alloy Wire.

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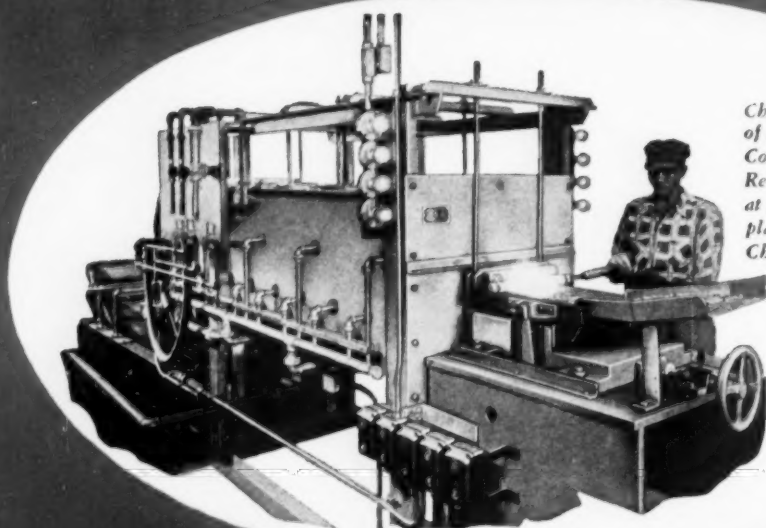
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METAL PROGRESS; PAGE 64

Metal Progress

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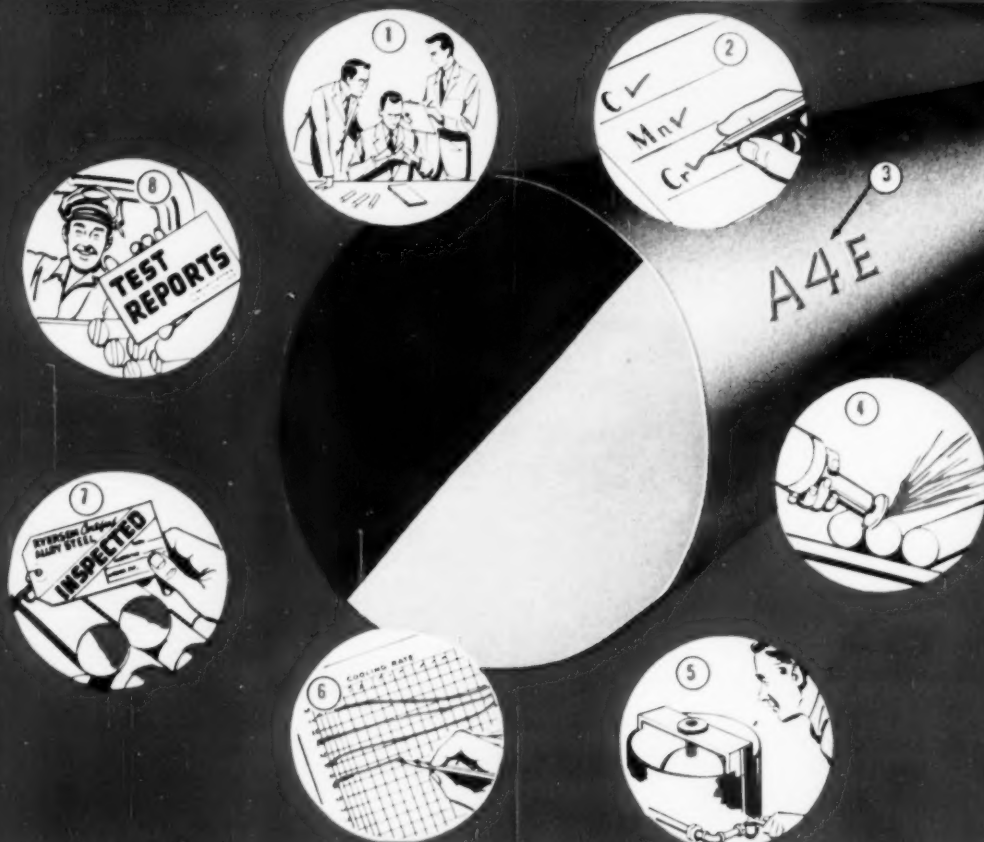
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By **WALTHER L. HAVEKOTTE**
Chief Engineer, High-Temperature Materials
Firth Sterling Inc., Pittsburgh

this study, they obtained exclusive United States licenses to prepare and market all types of titanium-carbide-base cermets produced by Hard Metal Tools, Ltd., Coventry, England, and by Metallwerk Plansee, Reutte, Austria. This paper deals with an evaluation of some of these cermets as part of a program for further improvement.

Test specimens were fabricated according to the following procedure: The 325-mesh titanium carbide and metal powders were ball milled together in steel mills using tungsten carbide balls and an inert organic liquid carrier. The powders were dried, mixed with

Super Refractories for Use in Jet Engines

ONE OF THE PROBLEMS associated with the jet engine is the urgent need for materials that will withstand higher temperatures than any of the materials now in use. There is little hope of obtaining a substantial improvement in the service life of the present alloys. The demand for such materials has led to numerous investigations on the combinations of metals and ceramics known as "cermets". Cermets have high strength-to-weight ratios and, for the most part, the constituents are easily obtained. The titanium-carbide-base cermets are being considered for jet-engine applications, especially for use as nozzle vanes. They possess high strength and resistance to oxidation at elevated temperatures. Their high thermal conductivity is valuable in dissipating heat and contributing to good thermal shock resistance. The biggest obstacle they must overcome is their poor resistance to impact.

Two years ago, Firth Sterling made a study of the refractory materials made in the United States, England and Europe to learn where they could best fit into the high-temperature picture. As a result of

paraffin, and pressed at room temperature. The billets were given a low-temperature sinter—1500 to 1800° F., depending upon the hardness desired—and shaped to the proper dimensions, keeping in mind that a shrinkage of approximately 20% occurs during the final sintering operation. The half-sintered specimens had to be handled very carefully because they were very fragile and only chalk hard. The specimens were then fully sintered in a vacuum furnace at a temperature above 2000° F., depending upon the amount of binder, and at a pressure of a few microns. Bodies were finish ground to shape using diamond abrasive wheels.

The chemical analyses and some mechanical properties of these cermets are shown in Table I. The titanium carbide content decreases from 63 to 43% as the amount of binder (Ni plus Co

Table I—Chemical Analyses and Mechanical Properties of TiC Cermets

GRADE	CHEMICAL ANALYSES, %					DENSITY G. PER CC.	ROCKWELL HARDNESS	MODULUS OF RUPTURE, PSI
	TiC	Ni	Co	Cr	Cr ₃ C ₂			
FS-2	63.0	29.6	—	7.4	—	6.00	A-87.2	175,000
FS-5	63.0	—	25.9	11.1	—	6.15	A-89.5	158,000
FS-8	63.0	22.2	7.4	7.4	—	6.05	A-87.5	162,000
FS-9	50.0	30.0	10.0	10.0	—	6.40	A-82.5	170,000
FS-26	54.3	40.0	—	—	5.7	6.25	A-85.0	165,000
FS-27	42.9	50.0	—	—	7.1	6.55	A-81.0	180,000

TiC Cermets

plus Cr) increases from 37 to 50%. Chromium imparts oxidation resistance to the cermets, and is relatively low on the list of strategic elements; it is less than 1% as strategic as columbium—another element used for this purpose.

The density varied between 6.00 and 6.55 g. per cc., depending on the amount and composition of the binder. The hardness ranged between Rockwell A-81 and 89. The modulus of rupture at room temperature varied from 150,000 to 180,000 psi. In general, as the amount of binder increased, the values for density increased, the hardness decreased, and the modulus of rupture strength increased.

Figure 1 illustrates a typical microstructure (Grade FS-27). Three phases are shown—titanium-carbide-rich solid solution, chromium-carbide-rich solid solution, and binder. The binder—a solid solution of nickel with a small amount of the two carbides—is represented by the white portions. Both carbides are gray and are differentiated by preferential etching. Electrolytic potassium hydroxide etches only the chromium carbide particles, leaving the titanium carbide and the binder particles unattacked.

A duplex structure of the titanium carbide

Fig. 1—Typical Microstructure of Grade FS-27 Cermet. White areas are nickel solid solution, gray areas titanium carbide solid solution, and small dark areas chromium carbide solid solution. Etched electrolytically in 8% oxalic acid; 1500×

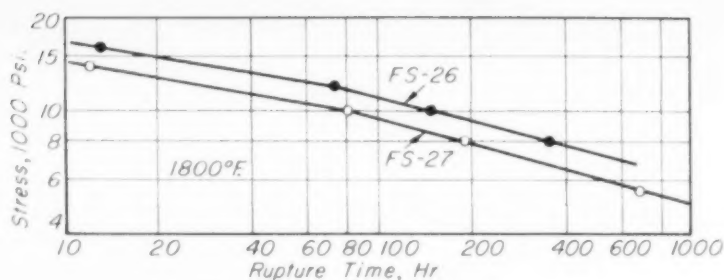
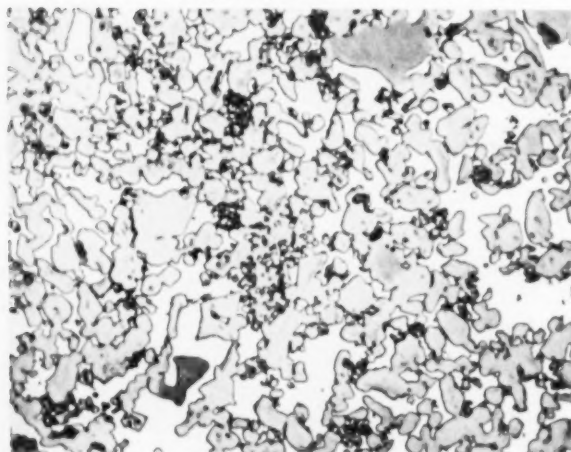


Fig. 2—Stress-Rupture Curves for Two Grades of Cermets at 1800° F.

particles can be obtained by etching in Murakami's reagent. The outside or dark areas are titanium carbide which go into solution and reprecipitate from the binder during the sintering operation. The center or light areas are undissolved titanium carbide particles which do not go into solution in sintering. The average size of the titanium carbide particles is approximately $2\frac{1}{2} \mu$.

The type of chromium carbide could not be identified by X-ray diffraction even though the specimen was powdered and the nickel binder removed by leaching. The amount of chromium carbide observed under the microscope was less than 5%.

The effect of temperature on tensile strength of FS-26 and FS-27 cermets is shown by the following data:

TEMPERATURE	TENSILE STRENGTH, PSI.	
	FS-26	FS-27
80° F.	33,000	75,000
800	41,000	76,500
1200	48,000	75,000
1500	51,000	60,000
1800	41,000	35,000

The specimens were $2\frac{1}{2}$ in. long by $\frac{1}{2}$ in. wide by 0.2 in. thick, with a reduced section of approximately $1.3 \times 0.2 \times 0.2$ in.; the ends of the specimens were V-shaped. The strength for FS-27 was fairly constant at about 75,000 psi. from room temperature to 1200° F., then dropped to 35,000 psi. at 1800° F. The reason for the increase in strength of FS-26 from 33,000 psi. at room temperature to 51,000 psi. at 1500° F. is not understood. It then dropped to 41,000 psi. at 1800° F. The elongation for both materials at 1800° F. was 1 to 2%. The specimens tested at lower temperatures showed no measurable ductility.

Figure 2 shows the rupture strengths for these same two grades at 1800° F. The same sized specimen was used for the stress-rupture tests as for the hot-tensile tests. The 100-hr. values of 9400 psi. for FS-27 and 11,100 psi. for FS-26

High-Temperature Properties

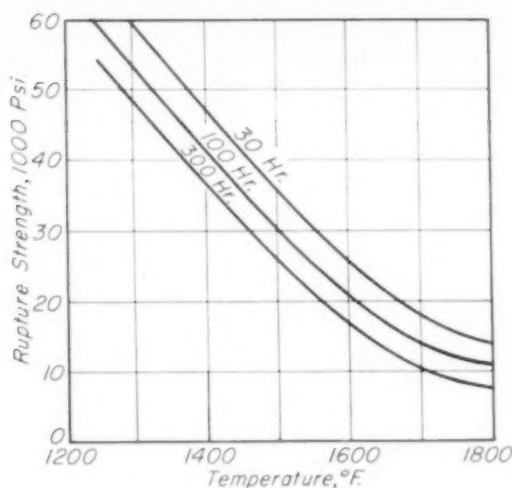


Fig. 3—Effect of Temperature on Rupture Strength of Grade FS-26 Cermet

do not represent the ultimate in rupture strengths. For example, our experience has shown that addition of molybdenum materially increases the strength of cermets at 1800° F. However, an increase in rupture strength is accompanied by a loss of ductility and impact resistance. The 100-hr. rupture strength for X-40—one of the best currently used alloys—is 11,300 psi. at this temperature. While the rupture strength for FS-26 compares favorably with X-40 at 1800° F., the cermet has a 26% lower density. This factor should be considered when comparing the cermets with metals, not only from the standpoint of weight saving in stationary parts, but also because low density is desirable in rotating parts to minimize centrifugal stresses. For instance, when a material having a 25% lower density is substituted for a second material, the stresses on the first material are reduced by as much as 25%.

In general, the ductility as measured in the stress-rupture test for these two cermets was fairly good; it ran from 3 to 8%. Better ductility was obtained with higher binder content of the cermet and with longer rupture times. Young's modulus at room temperature (75° F.) was 50.6×10^6 psi., and at 1300° F., it was 38.4×10^6 psi.

Figure 3 shows the effect of temperature on rupture strength of FS-26 for 30, 100, and 300 hr.

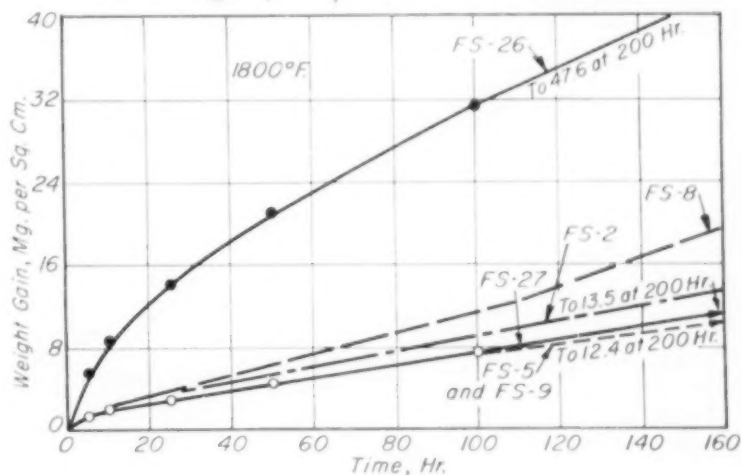
The 100-hr. rupture decreased from 59,000 psi. at 1250° F. to 11,100 psi. at 1800° F. At the lower temperatures, FS-26 is slightly stronger than alloy X-40, while at 1800° F. the two materials have about the same strength. Elongation increased from 1% for 300-hr. rupture at 1300° F. to approximately 8% at 1800° F.

FORMATION OF SCALE

Figure 4 shows the gain in weight when these cermets were exposed to moist air at 1800° F. for time periods up to 200 hr. Air flowed into the furnace at a rate of 2 liters per min. Specimens $\frac{3}{8} \times \frac{3}{8} \times \frac{1}{4}$ in. were placed in small aluminum boats, which were removed from the furnace at the end of 5, 10, 25, 50, 100, and 200 hr. In most of the tests the scale was strongly adherent, but when any scale flaked away, it was collected and weighed with the test piece. The curve for weight gain versus time shows a shape typical of the formation of a protective layer. FS-26 cermet gained 47.6 mg. per sq. cm. after 200 hr., while FS-27 gained only 13.5 mg. per sq. cm. FS-5 and FS-9 cermets, having the largest chromium contents, gained the smallest amount—approximately 12.4 mg. per sq. cm.

Metallographic examination indicated that oxidation began in binder areas adjacent to the carbide particles. It is believed that the binder areas were originally rich in chromium. During the time the specimens were sintered and later held at 1800° F., the chromium diffused into the carbide particles leaving the

Fig. 4—Oxidation Curves for Various Cermets Showing Gain in Weight After Exposure to Moist Air at 1800° F.



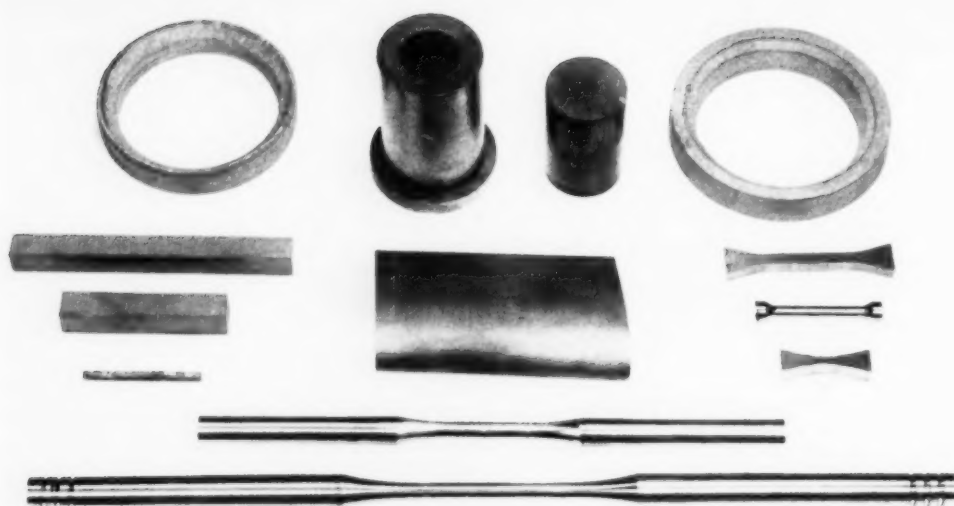


Fig. 5—Various Parts and Specimens Made of Titanium Carbide Cermets, Including Intake and Exhaust Valve Rings, Nozzle Vane, a Pump Bearing, Impact Bar, and Tensile and Stress-Rupture Bars

adjacent binder areas deficient in chromium. After the binder areas adjacent to the carbide particles had oxidized, the titanium carbide areas were affected next. Finally, the binder areas rich in chromium oxidized.

Coefficient of thermal expansion was measured on 2-in. samples with the results shown in the following tabulation:

TEMPERATURE RANGE	FS-26	FS-27
68-212° F.	5.6*	5.8*
68-392	5.9	6.0
68-572	6.0	6.1
68-752	6.0	6.0
68-932	6.0	6.1
68-1292	6.0	6.2
68-1472	6.0	6.2

* $\times 10^{-6}$ per ° F.

These figures are low when compared to most iron and nickel-base alloys, and offer the advantage that vanes and blades can be designed

with minimum clearance so they will not clash at high temperature.

The resistance to thermal shock of these cermets is good. This is surprising in materials with such low ductility, and must be attributed to the low thermal expansion and high thermal conductivity values, together with the fact that no structural transformations occur in these cermets on heating until the melting point is reached.

Unfortunately, cermets possess one serious drawback—namely, low impact resistance. Unnotched Charpy bars, 2.165 in. long by 0.394 in. square, of various cermet grades and of X-40 alloy were broken at various temperatures. The results shown in Table II reveal these cermets to be very brittle when compared to X-40, which is one of the most brittle of the commercial high-temperature alloys.

In conclusion, it is important to note that cermets with a range of properties can be produced by changes in composition. A variation in the amount of binder metal results in a change in toughness and resistance to thermal shock. The addition of alloying elements to the binder or to the carbide changes both strength and oxidation resistance. Probably no one composition will be ideal for all applications, but by adjusting properties in this way, the best compromise for a particular situation can be attained.

Table II—Toughness of Unnotched Charpy Bars

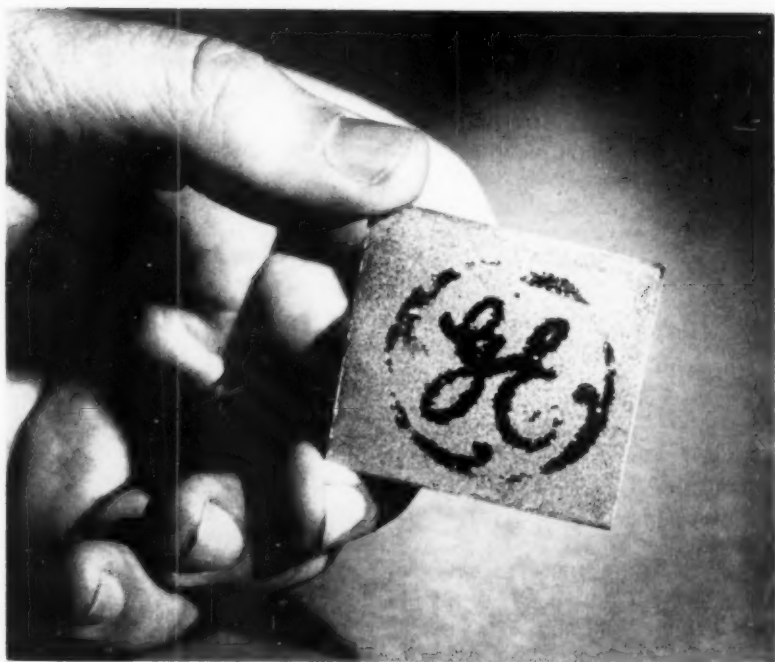
GRADE	IMPACT RESISTANCE, FT.-LB.				
	80° F.	800° F.	1200° F.	1500° F.	1800° F.
FS-26*	4.5	4.5	4.9	4.8	4.4
FS-27*	4.7	4.9	4.8	5.9	5.8
X-40 [†]	44.0	40.0	66.0	48.0	58.0

*Bars tested in a 16-ft.-lb. Baldwin machine. The hammer has a 2-ft. drop with a striking velocity of 11 ft. per sec.

[†]Bars tested in a 264-ft.-lb. Olsen machine. The hammer has a 4.4-ft. drop with a striking velocity of 16.5 ft. per sec.

By C. G. DUNN, Research Physicist
and G. C. NONKEN, Supervising Engineer
General Electric Co.
Pittsfield, Mass.

The G.E. Monogram Appears Essentially as a Single Crystal Against a Sparkling Background of Small Crystals in This Sample of Silicon Steel



Production of Oriented Single-Crystal Silicon Iron Sheet

WITHIN THE LAST decade, so-called grain-oriented silicon iron strip has become an important industrial product, by virtue of its magnetic properties, which approach those of a properly oriented single crystal. The marked improvement in magnetic properties of grain-oriented strip occurs when the path of the magnetic circuit coincides with the concentration of cube edge directions, since these directions in the crystal lattice are magnetically superior to other directions.

Properly oriented single crystals are, of course, ideal in this respect, and silicon iron in the form of single-crystal sheets represents what may be called the end point in the development of sharp single orientation textures.* Single-crystal sheets, however, cannot replace the cold rolled silicon iron with a sharp single orientation texture because single-crystal sheets are more difficult to produce, but they may find applica-

tions beyond those associated with the study of single-crystal materials.

A silicon iron sheet consisting of an "oriented" single crystal can be produced from a suitable polycrystalline sheet by recrystallizing it through the growth of a single nucleus. This "seed crystal" is previously grown in one end of the sheet and is mechanically positioned in the desired orientation by bending a portion of the sheet. (Dunn outlined part of this technique in

*The term "sharp single orientation texture", as used here, means that there is one and only one preferred crystal orientation and it is sharp or strong in contrast to a weak orientation, which begins to approach a condition of random orientations. If one expressed each degree of preferred orientation by a number, it would be the value of a standard deviation. For example, a single crystal would have a standard deviation of zero; a very strong preferred orientation, a standard deviation of, say, 5°; a moderately strong preferred orientation, a value of 15°. This field, however, has not yet reached the quantitative stage.

Growing a Seed Crystal

Transactions, A.I.M.E., Vol. 185, 1949, p. 72.)

The success of the method depends on several important factors:

1. The crystal-growing characteristics of the polycrystalline sheet material used.
2. The amount of strain introduced into the metal adjacent to the seed crystal, occupying a narrow portion called the neck, which is plastically bent in the reorienting process.
3. The temperature gradient employed to maintain continuous growth of the seed crystal in the range 1500 to 2000° F.

POLYCRYSTALLINE SHEET MATERIAL

As stated above, not all polycrystalline sheet materials have the required crystal-growing characteristics. Also, the method of fabrication should be taken into consideration since there is a relationship between preferred orientations required for crystal growth and the amount and



Fig. 1—Sheet of Specially Prepared Silicon Iron With Several Recrystallization Grains in One End. Dotted line shows outline of area to be removed if Grain B is to be used as a seed crystal

kind of hot or cold rolling and intermediate anneals. Regardless of these differences, the materials to be described in this article have in common a relatively fine-grained structure, which will be designated as the matrix.

A seed crystal must grow at the expense of the matrix under a driving force entirely derived from the grain-boundary energy of the fine-grained structure—or from a combination of grain-boundary energy and strain energy in the event that the matrix has been critically strained. If the driving force is to be constant, the matrix must be stable during growth of the seed crystal. This means that a portion of the matrix a small distance from the growing seed crystal must remain essentially unchanged during a high-temperature waiting period while the crystal traverses this distance. During the waiting period new grains must not appear in the matrix, and normal grain growth must not occur to any appreciable degree.

It is well known that the tendency toward normal grain growth increases with

approach to 100% purity or, conversely, that impurities can be used to retard normal grain growth. Presence of a sharp single orientation texture in the matrix will also stabilize the structure. Present materials, however, have no sharp single orientation texture, and whatever preferred orientations are present can only tend to stabilize the structure. It is almost certain, therefore, that some impurities are essential in our method of growing single crystals of silicon iron. Likewise any operation that helps prepare a uniform grain structure in the polycrystalline sheet material can be employed to advantage, since such a structure is more stable than a heterogeneous one.

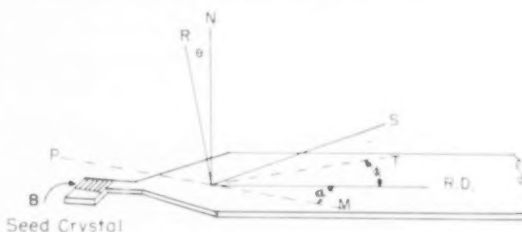
Three methods can be used to produce suitable sheet or strip material from commercial silicon iron with the following composition: 3.25% Si, 0.025 C, 0.034 Mn, 0.010 P, 0.017 S, 0.067 Ni, 0.068 Cu, 0.012 Sn, trace of Al and Cr. All three methods begin with a plate or band 0.10 in. thick that has been hot rolled from silicon iron ingots.

In Method I, pieces of the plate are reheated to about 1775° F. and hot rolled to 0.020 to 0.050 in. thick in packs. Sheets are annealed 15 to 20 hr. in hydrogen at about 1600° F. to remove residual stresses and lower the carbon content. After a critical tensile strain of about 2.5% elongation, the material is ready for use.

In Method II, the 0.10-in. hot rolled band is cold rolled to a final thickness between 0.020 and 0.050 in. in two steps. First, it is cold rolled to within 14% of the final gage and annealed for 20 min. (or less, depending on thickness) in air at about 1560° F. Scale is removed and it is then cold rolled the final 14%, annealed 1 hr. in hydrogen at 1475° F., and critically strained as in Method I.

In Method III, the band may be cold rolled to almost any desired final thickness in one or more stages. A penultimate open anneal in air at 1560° F. for a time long enough to reduce the carbon to about 0.005% is usually satisfac-

Fig. 2—Diagram Showing Directions R and S of Seed Crystal Relative to the Two Stationary Directions N and R.D. of the Sheet of Silicon Iron



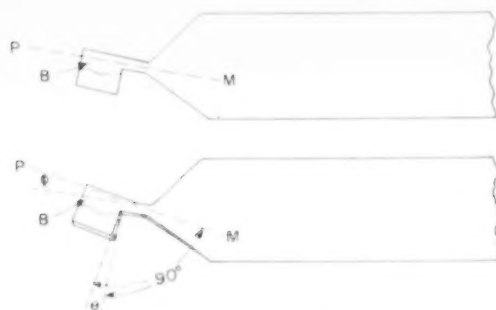


Fig. 3—Shape of Specimen and Isolated Seed Crystal Before Reorientation (Above) and After Reorientation (Below)

tory. Otherwise a decarburizing open anneal is recommended after the final cold reduction. The final reduction should preferably be in the range of 40 to 60%. Unlike Methods I and II, no critical strain is required; the matrix grain size produced by primary recrystallization is smaller and there is sufficient energy in the grain boundaries of the matrix to provide continuous growth of a single seed crystal. Although this method is the simplest of the three, it depends more critically on impurities and processing variations than the other two.

Method I is recommended if a wide variety of orientation is to be prepared or if a (100) or cube plane in particular is to be parallel with the sheet surface. On the other hand, if orientations are desired with the (110) or dodecahedral plane lying nearly parallel with the surface, then Methods II and III are recommended. A wider range of orientations can be obtained from Method II than from Method III, but if the cube-on-edge or (110) [001] orientation is desired, Method III generally is superior.

THE REORIENTING OF A SEED CRYSTAL

When silicon iron sheet prepared as described above is inserted a short distance into a high-temperature-gradient furnace, one or more recrystallization nuclei may be obtained, as shown schematically by A, B, C and D in Fig. 1. One nucleus—say grain B—may be selected as a seed crystal and its orientation determined. (For this purpose we prefer the transmission Laue method and the standard Laue patterns of Dunn and Martin described in *Transactions, A.I.M.E.*, Vol. 185, 1949, p. 417.)

After the orientation of the seed crystal has been found (preferably in the form of a stereographic plot of cube poles), two directions (R and S in Fig. 2) are located which in reorientation are to be brought parallel respectively to

Axes and Angles of Rotation

the normal and to the long dimension of the sheet. This is done with the aid of a Wulff net; also, the required axes and angles of rotation for the reorientation can be determined easily using the Wulff net. If the final orientation is to have a cube plane in the plane of the sheet and a cube edge direction parallel with the long dimension of the sheet—a (100) [001] orientation—then both R and S will be cube edge directions. Another specific example, a (110) [001] orientation, would require R to be a face diagonal direction and S a cube edge direction. In general, however, R and S are two unspecified directions, 90° apart.

Putting a direction N normal to the sheet and a direction R.D. parallel with the long dimension, one obtains from the orientation analysis the relationships shown in Fig. 2. The directions R and N determine an angle of rotation θ and an axis of rotation PM, which is 90° to both R and N. PM makes an angle ϕ with R.D. When R has been rotated to N, S falls at T, which is at an angle Φ with R.D. Therefore a rotation of θ degrees about PM followed by a rotation of Φ degrees about N makes R coincide with N and S coincide with R.D., giving the required final orientation. If the Φ rotation is taken first so that T coincides with R.D., the axis PM for the final rotation is found displaced Φ° either toward or away from R.D., depending on the direction of rotation.

Knowing the position of the axis PM and the amount of rotation required about N, one can plan how to isolate the seed crystal to minimize crystal growth 90° to R.D. The seed crystal is isolated by cutting away portions of the sheet as illustrated by the position of the dotted lines in Fig. 1. Generally, the axis PM either should be nearly parallel with the narrow portion (a neck portion adjacent to the seed crystal) or should be nearly perpendicular to the narrow or neck portion.

Figure 3 illustrates the former situation, and shows the shape of the sheet specimen after it has been cut along the dotted lines of Fig. 1. At this point all edges need to be heavily etched to remove excessively worked metal; otherwise unwanted nucleation may take place during crystal growth.

The apparatus used to reorient a seed crystal is shown in Fig. 4. A clamp holds and rotates the seed crystal and a table holds the end of the sheet adjacent to the neck portion. When the lower scale, which measures angles of rotation about N, is set correctly at the angle θ so

Improved Reorienting Apparatus

that the horizontal axis coincides with the direction PM, the sheet specimen is placed on the table with its sides parallel to the reference lines and with the seed crystal resting freely in the jaws of the clamp, which at this point is at a zero setting of the upper scale. The jaws of the clamp are closed on the seed crystal, and the neck portion is bent as described previously.

During the reorientation operation the neck portion should be at red heat to facilitate plastic flow and minimize work hardening. Too high a temperature, however, would precipitate recrystallization, destroying the correct matrix structure. A small flame is adequate to apply heat locally; we use an oxygen-acetylene torch (Style 90, No. 4 tip), fed with natural gas instead of acetylene. After the two rotations have been completed, the specimen is fed, seed crystal first, into a furnace with a high temperature gradient for the final annealing operation.

The crystal reorienting apparatus of Fig. 4 was developed for this investigation and appears to have certain advantages over other devices of this kind. Fujiwara and Tiedema in their work on aluminum have described devices that require two rotations to bring the direction R of Fig. 2 parallel with the normal N. Their apparatus is described in *Journal of Science*, Hiroshima University, Vol. 11, 1941, p. 89 and *Acta Crystallographica*, Vol. 2, 1949, p. 261. The sum of these two rotations can be proved to be larger than the equivalent single rotation about the axis PM. Hence, if only one direction

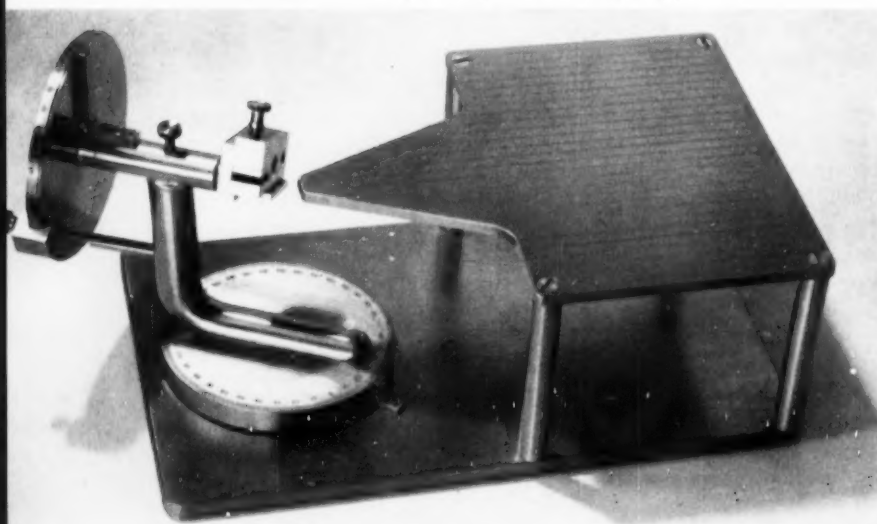
R is to be fixed, rotation about a single axis, in the manner we recommend, minimizes the strain imposed in the neck portion. Fujiwara and Tiedema do not consider the second step, namely, the fixing of the direction S. If a third rotation is added to their two rotations, the straining of the neck portion is greater than that produced by using two rotations as described here. Our crystal reorienting apparatus can be made to do even more, because the two rotations may be carried out simultaneously instead of in succession, the result approaching that of a single rotation. A single rotation giving the required reorientation produces the lowest possible strain.

There are limitations in the shape of the neck and seed crystal portion of the specimen that the reorienting apparatus must also meet. The specimen must be able to pass through the small furnace apertures that are necessary to maintain a high temperature gradient. Except for this, the strain in the neck portion could be distributed over any size neck desired. In test experiments, successful results have been obtained after total rotations of more than 90°, which is more than ever is required. The main limitation to the amount of permissible rotation usually stems from the crystal-growing characteristics of the material. Twinning to a twin orientation during growth also is a problem.

As in other methods of producing single crystals, speed of growth is an important factor. In the temperature range for growth (above about 1550° F.) the temperature gradient decreases with increase in temperature, making it difficult to grow crystals at higher temperatures and therefore higher speeds. It is clear, therefore, that the higher the temperature gradients obtained the higher will be the permissible rate of growth.

Conversely, with a specified speed (that is, the rate at which the sheet is moved into the furnace), the higher the gradient at the growth temperature, the greater will be the chance for success. Much of our work has been done at speeds of about $\frac{1}{4}$ or $\frac{1}{2}$ in. per hr., but considerably higher speeds have been found practical for certain purposes.

Fig. 4—Crystal Reorienting Apparatus



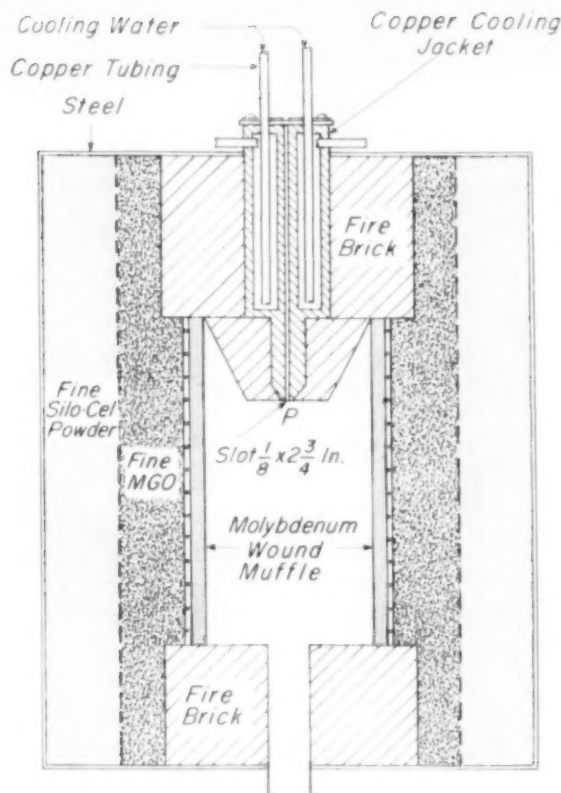


Fig. 5 - Cross Section of High-Gradient Furnace (22 1/2 In. High) for Growing Single Crystal

A furnace designed for growing a single large crystal in sheet form from a reoriented seed crystal must not only maintain a high temperature gradient in the range between 1500 and 2000° F., but must also meet certain other requirements such as good temperature control and stability, a hydrogen atmosphere, and a means of carrying the strip slowly and steadily into the furnace.

Figure 5 shows a cross section of a furnace which has been in use for a number of years. It consists of an alumina cylinder muffle wound with molybdenum wire and embedded in insulating refractory powder. A water-jacketed copper block which extends into the furnace to the point P forms the entrance slot for the silicon iron strip. Circulating water keeps the copper cool, and

High-Gradient Furnace Design

since the entrance slot extends well into the hot part of the furnace, the temperature increases very rapidly beyond point P.

Temperature variation with position in the furnace and its rate of increase measured from point P are shown in Fig. 6 for a given power input. If continuous growth occurred at a temperature of 1750° F., for example, the temperature gradient at the point of growth would be 1800° F. per in. With higher entry speed of the sheet, the temperature for growth would be higher, but the gradient would be lower.

SUMMARY

The steps for producing a large oriented single crystal of recrystallized silicon iron prepared by one of the three methods described may be summarized as follows:

1. One or more crystals are obtained in the end of a sheet (or strip) by placing it into the hot portion of a furnace with a high temperature gradient.
2. The sheet is removed and one crystal is selected for the seed crystal. It must be adjacent to the matrix.
3. A transmission Laue pattern of the seed crystal is obtained.
4. The orientation of the seed crystal is obtained from the Lauegram and the axes and angles of rotation to bring the crystal into the desired orientation are determined with the aid of a Wulff net.

5. The unwanted crystals are cut away as shown in Fig. 3, leaving the seed crystal connected to the strip by a narrow neck.

6. The seed crystal is clamped in the crystal reorienting apparatus (Fig. 4) and is changed to the desired orientation with respect to the sheet, by bending the neck of the specimen while at red heat.

7. The seed crystal in the new orientation is then made to grow and replace the matrix of the entire sheet by passing the sheet slowly through the hot zone of a high-temperature-gradient furnace.

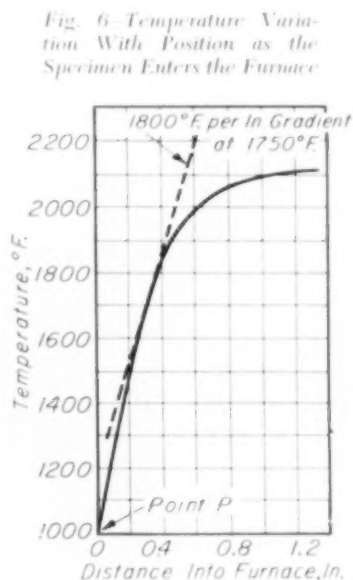


Fig. 6 - Temperature Variation With Position as the Specimen Enters the Furnace

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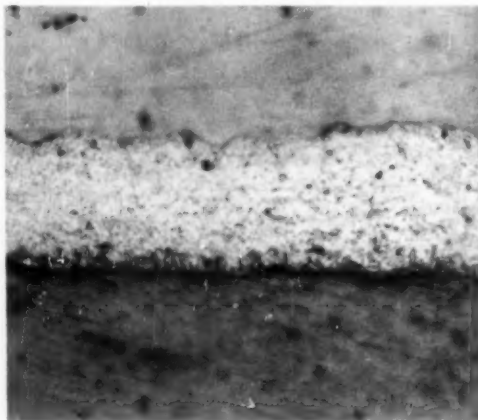
Electroplating Prior to Hot Galvanizing for Improved Results

AS EARLY AS 1844 an American patent was granted on a process for the electroplating of tin on an iron object prior to its being dipped in molten zinc or other hot metal. Several patents have been granted during the last 100 years dealing with the idea of using various metals for electroplating the iron object to be ultimately hot galvanized. In the opinion of the inventors, such a preliminary electroplate would assure a more satisfactory final coating.

More recently, the practice in hot galvanizing has been to introduce another metal in quantities much less than 1% into the molten zinc and depend on its presence for such beneficial effects as are sought. The use of aluminum in this fashion has become a broad practice because it has resulted in the production of hot galvanized coatings of distinctive and desirable characteristics. Consequently, experiments were undertaken with a view of determining whether introducing some of these metals in "trace" amounts as an electroplated film might lead to the development of other methods of finishing those products which generally are hot dip galvanized by a continuous operation.

These studies were based on certain familiar assumptions concerning the conditions which influence the adherence and ductility of the hot dip zinc coating. Basic among these are the assumptions that the solubility of the iron in the zinc and the diffusion of this dissolved

Fig. 1—Commercial Hot Galvanized Steel. Immersed for about 3 sec. at 850 to 860° F. in zinc containing 0.12 to 0.15% Al. All micros 1000×



iron throughout the coating are important. Attention is directed, therefore, to the temperature of the zinc bath, the immersion time, the solubility and diffusion of the iron in the zinc, and the effects of minor amounts of other metals on the nature of the coating. Since facilities were available for electroplating thin films of various metals on steel panels, the experiments began at this point. This article is a record of the outcome.

Panels of A.I.S.I. 1010 having a high finish and measuring 0.029 x 3 x 8 in. were used in these studies. The coatings listed below were put on both sides of the panels by standard commercial plating methods.

METAL PLATED	THICKNESS, IN IN.	WEIGHT, OZ. PER SQ. FT.
Zinc	0.000033	0.02145
Tin	0.000033	0.02003
Nickel	0.00002	0.01442
Iron	0.0002	0.1300

The plate thicknesses were chosen as ones quickly and readily obtained, and the intention is to continue the study by using other values which may be either thinner or thicker. In production, the thought is to follow any pickling or other cleaning step with a suitable plate so that the strip steel could be preheated if desired, and could possibly be prefluxed and enter the molten zinc through a flux blanket.

Panels plated in our laboratory have been hot dipped successfully several days later without further treatment by passing them through a fusion of No. 20 flux on the molten zinc at 845 to 850° F. The galvanizing unit used held 20 tons of zinc ("Prime Western") in which there

Experimental Procedure

may have been very minute traces of aluminum from additions that were made during its use prior to the tests.

Unplated panels of the same steel as used under the plates provided a basis of comparison for the two methods of galvanizing. The electroplated iron was included to note if such a surface increased the diffusion of iron through the final coat. Zinc plating was used to note the possibility of minimizing the content of diffused iron. Tin was tried because it is another metal commonly used in small amounts to increase the effectiveness of the galvanizing. Nickel was used since it is easily applied in thin films and would favorably permit preheating. This series would have included aluminum as a thin film, but because it is not readily electroplated, its performance will be observed after another method of application of a thin film can be carried out.

The samples not plated and those with an electroplated film of iron were first dipped in a No. 20 flux wash. The other electroplated samples were not given the preflux dip. To control the dipping time, each plate had a heavy weight wired to one corner and another wire attached to the corner diagonally opposite for use as a handle. When the weight had lost buoyancy, the plates were allowed to sink vertically through the fused flux layer and remain in the hot zinc for the predetermined times. These are given in the captions for the micrographs. The original plates weighed approximately 90 g. each, and after coating weighed

Fig. 2—Coated by Sendzimir Process in 4 Sec. at 850 to 860° F.

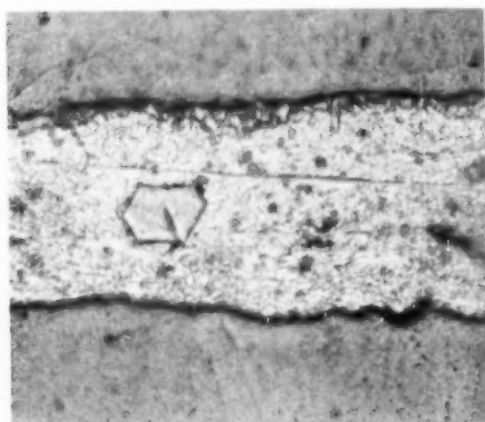
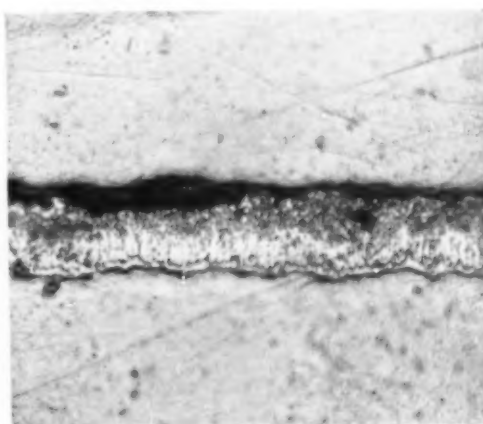


Fig. 3—Coated in Lead-Zinc Bath, Immersion in Zinc Layer (Containing no Aluminum) Less Than 1 Sec.



Preplating for Galvanizing

approximately 104 g. They were quenched in hot water immediately after removal from the molten zinc.

Because immersions ranging from 7 to 9 sec. were required to secure a completely smooth coverage, 10 sec. was adopted as a uniform minimum time. This was a disappointment because immersion times less than 5 sec. had been sought; it appears, therefore, that a continuous process would require some preheating of the strip in order to keep immersion time at a minimum. When the samples were withdrawn from the zinc bath, the hot metal ran off the surface of the panels plated with tin and nickel more freely than from the others.

It was felt that micrographic examination of

sections of each group would be more useful than an evaluation through adherence or bending tests on such small plates with their heavy weight of coating. These micrographs are Fig. 4 to 8. All metallographic samples were mounted similarly and, with the plated ones, the three tests of each lot were included in a single mounting separated by steel spacers. Magnesium oxide ("Shamva") was used in polishing. Etching was done with a fresh mixture of 25 ml. of amyl alcohol and 1 drop of concentrated nitric acid for 10 to 20 sec. An oil immersion objective of NA 1.3 was used and exposures were made on "ortho commercial" plates (sensitive to blue) through a blue filter.

Figures 1 and 2 are typical of currently produced commercial quality galvanizing on steel by methods using aluminum as a means of coating control. Figure 2 shows the Sendzimir-process coating; Fig. 3 is of a coating obtained on a narrow strip passing through a lead bath for about 10 ft. and emerging through a thin layer of molten zinc. Here, total time in the hot metal is about 8 sec., of which less than 1 sec. is spent in the zinc layer. The coating in Fig. 3 is about 0.0006 in. thick and weighs 0.36 oz. per sq.ft. The close similarity of the structure to that shown in Fig. 4 for unplated panels suggests the thought that the passage of this strip through the lead section of the bath initiated the attack on the base iron. Otherwise, it is reasonable to assume that a regular series of zinc phases is created in less than 1 sec. at about 850° F.

The structure for plain steel in Fig. 4 appears to be that usually reported for hot dip zinc coatings where there is little or no aluminum present. At the time these exposures were made, it was apparent that what appears here as the first zone (gamma) above the steel base was in reality a divided one with a finer line also running in a horizontal direction. However, because no structural difference could be detected in the surfaces below the higher one of these lines, it was decided to present the micrographs which illustrate the areas of greater diffusion more clearly.

The effect of the electroplated iron film is shown in Fig. 5. Study of the sections and the prints gives the impression that the diffusion has been more uniform, and possibly the layers up to the eta phase are thicker than on unplated

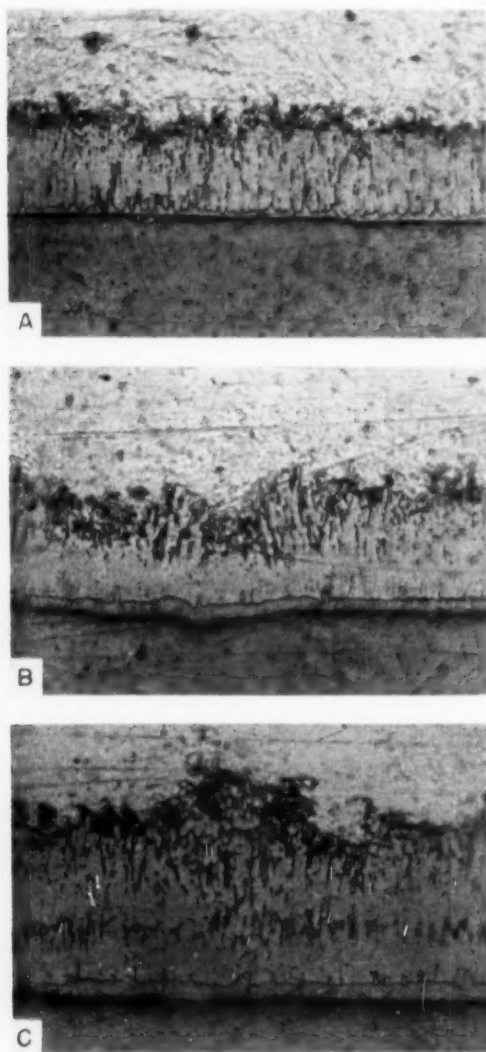


Fig. 4—Samples Without Preplate, Galvanized at 850° F. for (A) 10 Sec., (B) 30 Sec., (C) 60 Sec.

Micros Compare Various Metals

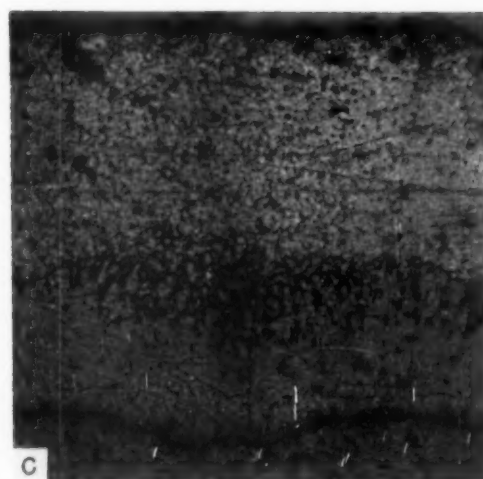
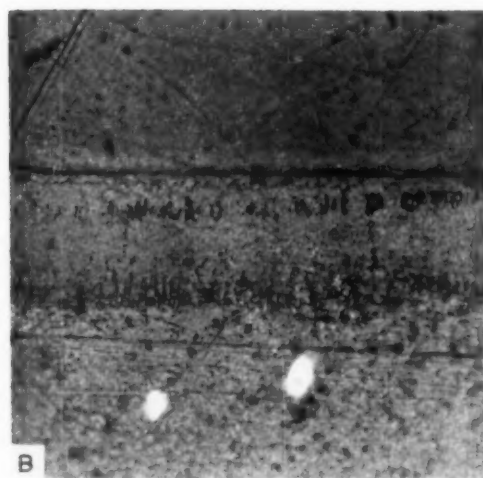
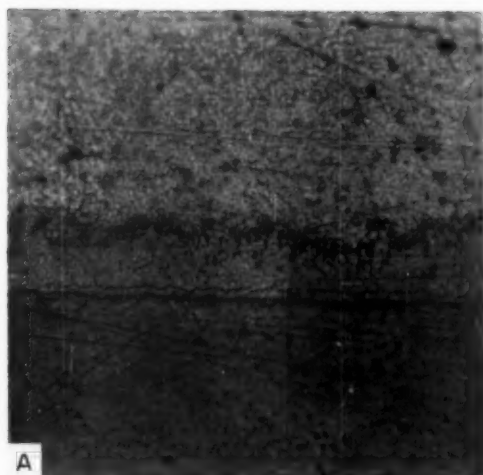


Fig. 5—Preplated With 0.0002 In. of Iron, Galvanized at 850° F. for (A) 10 Sec., (B) 30 Sec., (C) 60 Sec.

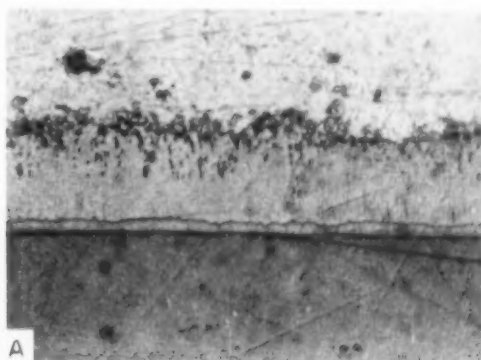
steel. At 60 sec. immersion there appears to be a tendency for the gamma layer to lose its smooth, uniform appearance.

The general preference in industry to have tin available for additions to the molten zinc led to including this metal in the series, and the usual highly fluid condition of metal draining from the test panels was met. Figure 6 shows sections of two tests; attention is drawn to the diffusion pattern at the upper edge of the gamma layer for the sample receiving 60-sec. immersion (Fig. 6B).

The panels electroplated with zinc are shown in Fig. 7. These coatings seem to have horizontal lines of phase separation which are more even and uniform. The vertical structure appears denser and less displaced from the vertical.

Probably the most interesting test was on the nickel plated panels, the results of which are shown in Fig. 8. There is a very thin film next to the steel base which does not show clearly here. In Fig. 8A (10-sec. dip) discrete particles seem to be suspended in a second mass. After

Fig. 6—Preplated With 0.000033 In. of Tin, Galvanized at 850° F. for (A) 16.8 Sec., (B) 60 Sec.



Heat Requirements for Galvanizing

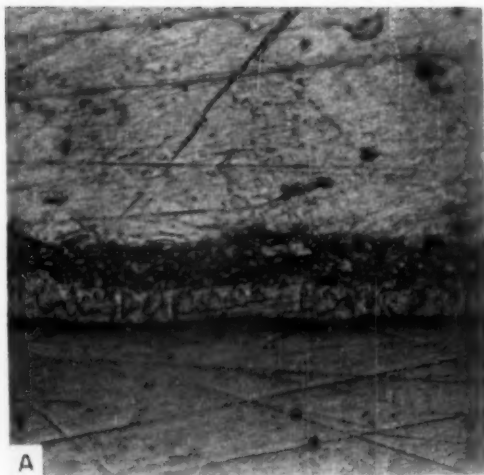
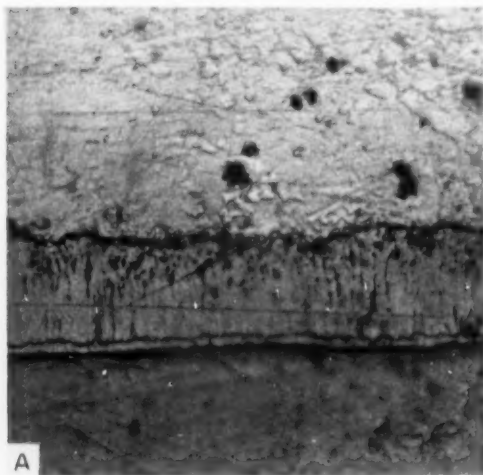
30 sec. of immersion (Fig. 8B), this area has become more uniform, and in 60 sec. (Fig. 8C) these particles have taken on a distinct dog-tooth shape and have moved away from the steel base. Reference to the nickel-zinc phase diagrams by J. Schram (*Zeitschrift für Metallkunde*, Vol. 30, April 1938, p. 132) discloses a eutectic at 418.5° C. with 0.04% Ni in the eta phase of Zn and 0.25% Ni in the liquidus.

At this time we do not feel justified in drawing many definite conclusions from these experiments or from the micrographs. Some impressions have arisen, however, which we feel will justify the continuation of studies in this direction. Some of these are:

1. Electroplated films may be used to improve the process of hot galvanizing strip steel by protecting the treated surfaces of the steel prior to coating. Any steel surface must be completely free of oxide and nonmetallic materials before galvanizing. If it is not, molten zinc will not alloy with the ferrous surface. Surfaces can be freed of iron oxide by ordinary pickling, but under ordinary conditions, particularly where continuous methods are in use, iron surfaces tend strongly to re-oxidize. A film of nonferrous metal plated to the ferrous surface can retard, and possibly prevent, the formation of any iron oxide on the surface. The film itself might oxidize, but these oxides would not be as harmful.

2. No radically new phase pattern appears in the coatings, except possibly with nickel.

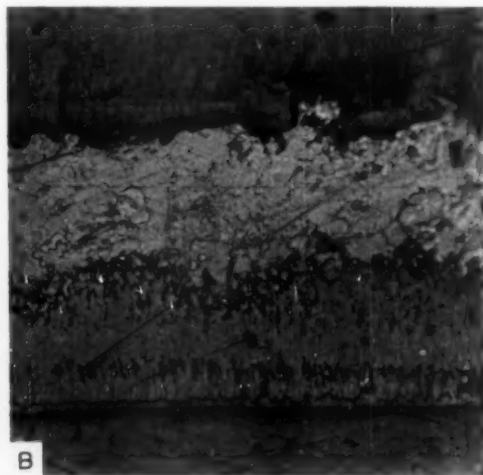
Fig. 7—Preplated With 0.000033 In. of Zinc, Galvanized at 850° F. for (A) 10 Sec., (B) 30 Sec., (C) 60 Sec.

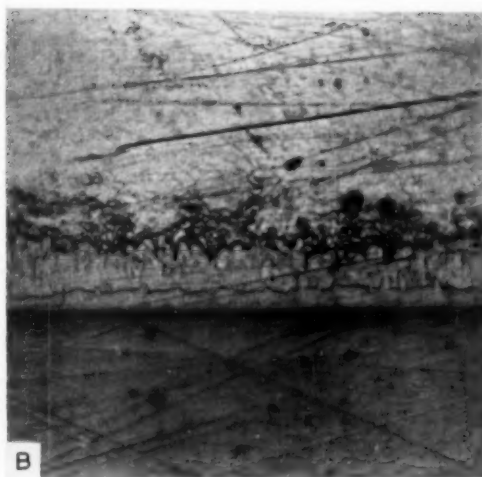


3. Thin electroplated surfaces can be used as a means of establishing a desired surface for hot galvanizing.

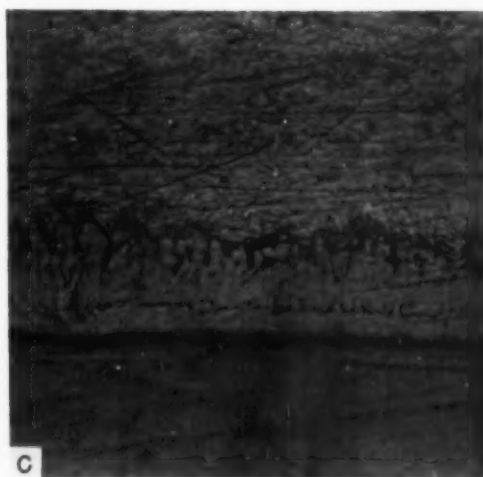
4. A method of measuring the effect of time and temperature on the diffusion of iron or other metal through the zinc coating might be developed. Apparently, as the phases form, the boundaries between them are irregular, then with time become more regular and with still longer time lose this regularity. By "regularity" is meant the smoothness or evenness of the lines separating the phases.

The place where coating quality is finally established is in the zinc bath itself, and a feature of the existing processes for steel strip is the success they have in presenting uniform surfaces to molten zinc for coating in short immersion times. These experiments indicate that it is de-





B



C

Fig. 8—Preplated With 0.00002 In. of Nickel, Galvanized at 850° F. for (A) 10 Sec., (B) 30 Sec., (C) 60 Sec.

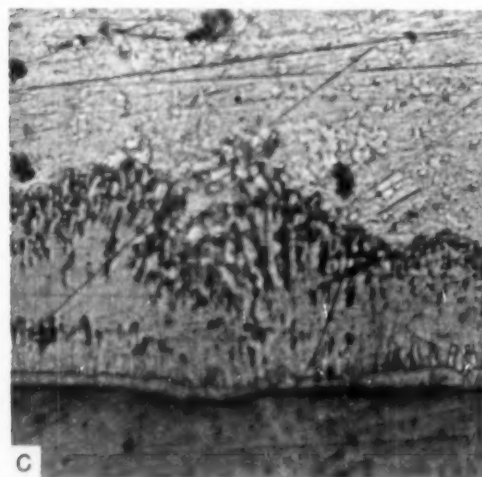
sirable to keep the immersion period shorter than the full time required to bring the steel itself up to zinc kettle temperature. This means preheating, which in turn calls for maintenance of the proper steel surface, as apparently is done by a preliminary electroplate of a thin film. Such electroplated surfaces can be preheated rather simply, but probably not to the temperature of the molten zinc.

In practice, the total requirement to heat a pound of steel and melt the zinc to coat it ranges from a possible low value of 180 Btu. to approximately 500 Btu. when the heat is supplied through the side walls of the pot. Highly efficient installations require 200 to 350 Btu. per lb. of work.

This use of about double the basic heat requirement wherever heat is supplied through

the side walls invites consideration of heating methods where the heat source functions by direct radiation on a properly protected zinc surface. The use of electric resistors as described by N. Thoren ("Top-Heated Galvanizing Bath at Virsbo", Preprint No. 6, Düsseldorf Conference, 1952) illustrates one application of this type. Records derived from substantial quantities of production indicate total heat requirement of 150 Btu. per lb. where approximately 12,000 Btu. is released for each square foot of heating area. It would appear, therefore, that the initial accomplishments by this method of heating would justify consideration of it as a more efficient and better controlled heating at the actual point of use.

In conclusion, it should be repeated that these experiments were undertaken to determine if very thin electroplated films would be useful in carrying out the hot galvanizing operation. Such a study would call for consideration of the various steps in the hot galvanizing process and has led to the comments on heat application. As for the other steps, the insertion of an electroplating stage does not present complicated or costly problems in methods. Likewise, the decision to preflux and to maintain a flux fusion on the molten zinc will be influenced by the selection of materials suitable for operation on nonferrous surfaces. This, of course, is a different problem than that met with ferrous surfaces and broadens the possibilities of selection. Finally, these experiments must be looked upon as merely the first step in a continuing development program.



C

A Method of Metallurgical Microspectroscopy

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TO ASSIST metallurgists in identifying microconstituents of metallurgical specimens, spectroscopists for several years have been working on the problem of obtaining a sample restricted to a very small area of the specimen. G. Scheibe and J. Martin devised specialized equipment as early as 1939 (*Spectrochimica Acta*, Vol. 1, 1939) to obtain such a sample. Their procedure employed a microspark source which discharged through a fine quartz capillary onto the area to be analyzed. Surface areas of 0.05 mm. diameter were reported to be successfully identified. Later, others (*Journal of the Optical Society of America*, Vol. 31, 1941 and Vol. 37, 1947) employed modified versions

of this method. In 1941 G. Thanaheiser and J. Heyes (*Archiv fur das Eisenhuttewesen*, Vol. 14, 1941) reported using a small hole drilled through a thin mica sheet to confine a spark to a small area of metal. Barker, Convey, and Oldfield, in a series of publications (*Engineering*, Vol. 152, 1941, and Vol. 160, 1945, and *Iron and Steel*, Vol. 18, 1945) reported the use of pointed graphite and metal counter electrodes for the analysis of segregates in metals. Hurwitz has continued work on the quantitative determination of segregation in metals (*Journal of the Optical Society of America*, Vol. 42, 1952) by means of traversing metal surfaces with a microspark, thereby obtaining spectra from a path 0.6 mm. wide.

One of the difficulties encountered by spectroscopists in using the methods reported by these investigators has been the necessity of constructing specialized equipment. The procedure to be described has the advantage of utilizing any standard spectrograph and source. The small amount of specialized equipment needed is available commercially.

PRINCIPLE OF THE METHOD

This new method of identifying metallic constituents consists of drilling out the minute portion to be analyzed, flowing collodion over the resulting chips, and transferring the collodion together with chips to

Fig. 1—Microdrilling Machine for Sampling Metallurgical Specimens

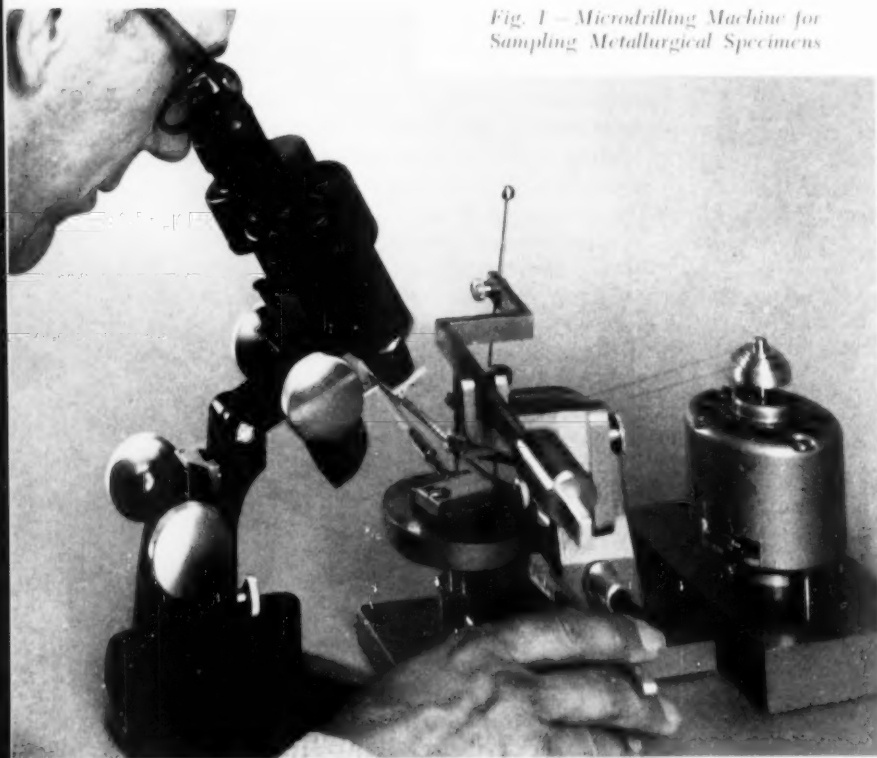


Fig. 2(A)—Mounted Cross Section of Silver Solder Sheet With Sample Chips Made With 0.003-In. Microdrill

a pure carbon electrode for analysis in a standard spectrographic arc.

The steps of the sampling procedure are illustrated in Fig. 2 in which (A) is a mounted section of silver solder sheet consisting of a center strip of 0.005-in. copper between two layers of 0.003-in. silver with chips drilled from the copper layer by means of 0.003-in. diameter microdrill, (B) is a portion of a collodion droplet covering chips, and (C) is the hole remaining after collodion and embedded chips are stripped from the specimens. The simple metallic spectrum of pure copper is obtained when the collodion and chips are arced in a graphite electrode.

Because 0.1 microgram of metal can usually produce a spectrum, drillings from a 0.001-in. diameter hole of equal depth can usually be identified as to major constituent. Drillings from 0.002 and 0.003-in. holes often provide more complete spectra and identification of high-alloy constituents.

DRILLING MACHINE

Several drilling machines reported to be capable of utilizing 0.001-in. drills are commercially available. The one used in this work was National Jet Co.'s Model 7A, (Fig. 1), and is capable of drilling holes as small as 0.00025 in. in diameter in relatively soft steels. The mechanism employs no chuck, but instead spindle and drill are a single concentric piece which revolves in a jeweled V-block. The motor is mounted separately from the drilling machine to provide essentially vibration-free spindle speeds from 2500 to 5000 rpm.

Pivot drills of tungsten steel, hardened to Rockwell C-65 to 68 are used in sizes ranging from 0.001 to 0.005 in. in diameter. The shank itself becomes the spindle of the machine.

The microscope used in viewing the sample and drilling operations is a Spencer stereoscopic shop microscope equipped with 18 \times paired eyepieces. Visual magnification is selected to match the leverage ratio of the drill controls, as well as to allow identification and centering of the sample area to be drilled.

Sample Preparation—The constituent to be identified is usually first observed in a mounted and polished specimen prepared for micro-

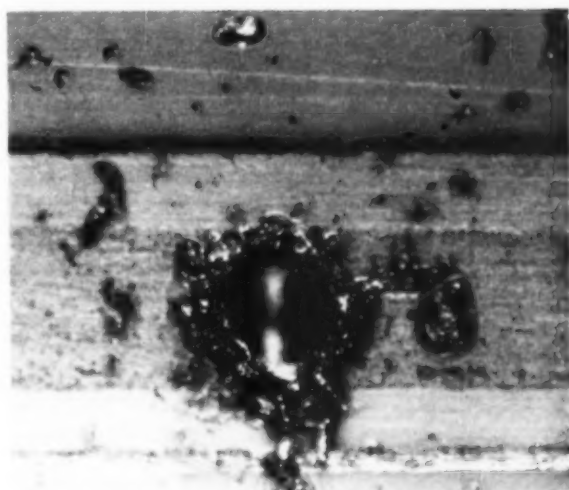
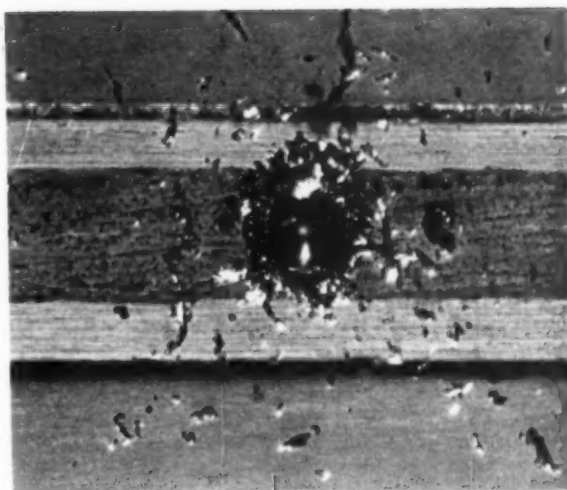


Fig. 2(B)—Metallic Chips Embedded in Collodion Droplet, Collodion and chips ready for removal and burning in spectrographic arc

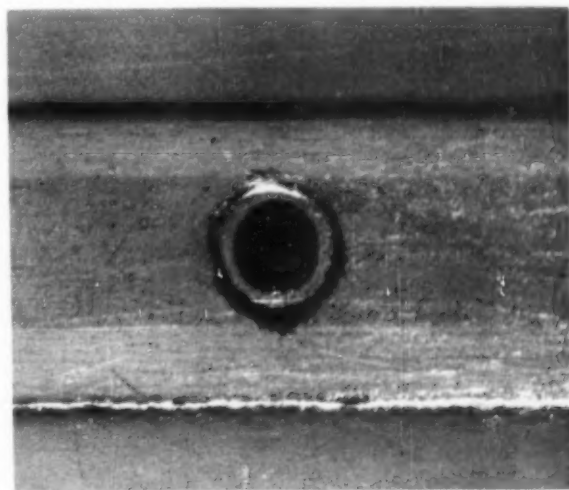


Fig. 2(C)—Hole Remaining in Specimen After Stripping Collodion and Embedded Chips

Quantitative Analysis of Constituents

scopic examination. The typical metallographic mounting for the specimen also provides a very satisfactory means of manipulating the sample in the drilling machine. The small area to be analyzed spectrographically is first located by the metallurgist under the metallographic microscope before the specimen is transferred to the microdrilling machine.

The size of the area to be sampled and the appropriate drill size can be determined by viewing the specimen under a known magnification. In general, drill size is selected to be equal to, or less than, the surface area to be removed. The simplest qualitative analysis is derived from a single drilling restricted to the individual area in question. Qualitative information can also be obtained when drill size is relatively large as compared to the unknown constituent, provided a second drilling from the surrounding material is used for comparison.

Quantitative analysis requires sufficient drilled material to provide a more complete spectrum than required for qualitative identification. If the unknown constituent occurs in large formations, a single large drilling may provide a suitable spectrum for quantitative estimations. If the unknown constituent exists only in very minute areas, an appropriately located series of drillings of smaller diameter will provide the necessary mass of representative material necessary for quantitative results. At best, however, quantitative results by micro-spectroscopy are quite inaccurate as compared with conventional spectroscopy.

Drilling Techniques — Drilling must, of course, be confined to the proper area and depth, and a satisfactory quantity of chips should be obtained. Equally self-evident is that the drill be of appropriate diameter and, as an aid in controlling hole size, be reasonably straight to avoid excessive run-out. To control the exact location of the hole, the microscope should be focused on the surface of the specimen so that it and the drill tip are in focus at time of contact. The bottom of the specimen mount should be flat to prevent wobble, and to offer sufficient friction to prevent its rotating under the drill. Also, the surface of the specimen should be perpendicular to the axis of drill rotation to prevent sliding and bending of the drill as it contacts the sample. A long pulley-cord and rigid table are of some advantage in minimizing the transfer of motor vibration to the drill.

As a rule, any visible chip is sufficient to pro-

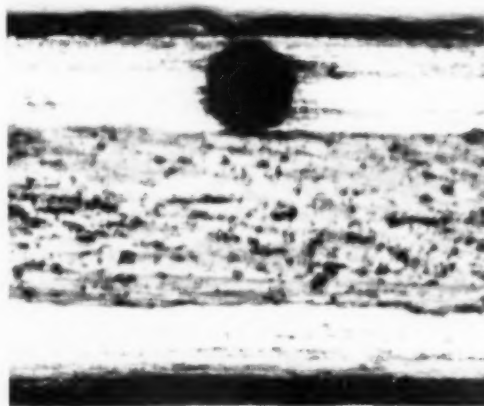
vide a qualitative spectrum of the major metallic element. Recovery of sufficient chips from very small holes requires that the spindle speed be low enough to prevent chips from scattering too far from the hole. On the other hand, chips sometimes cling to the drill and defy removal when the drill becomes magnetized.

There are several factors which can lead to frequent drill breakage. Under similar conditions, the smaller drills, of course, break more easily than the larger ones. Samples approaching the hardness of the drill are particularly hazardous and should be drilled by imparting a reciprocating action to the drill point. Spindle speed should be less than 3000 rpm, rather than higher, according to Cupler (*Tool Engineer*, April, 1950). Carbon tetrachloride is considered the best lubricant and coolant, and the quantity required should not be excessively toxic.

Recovery of Chips — After drilling is completed, a drop of 10% solution of flexible collodion in butyl acetate is flowed over the chips. Within a few minutes, the collodion, together with embedded chips, can be stripped from the surface of the specimen. Other organic strip-pable films may be used, providing the material does not contribute to the metallic spectra. Likewise, solvents other than butyl acetate may be employed to hasten or retard the rate of evaporation.

Electrode Preparation — The collodion-embedded sample is placed on the end of a spectroscopically pure graphite electrode and moistened with a drop of butyl acetate for improved adhesion of the collodion to the electrode. (Even the best graphite electrodes contain traces of metallic elements; therefore it is

Fig. 3 — Hole Resulting From Removal of Sample From 0.003-In. Layer by Means of 0.002-In. Microdrill. Silver, copper, zinc, and cadmium were identified in sample



Microdrilling for Small Samples

wise to use the highest purity obtainable.) It is advisable to arc a pair of bare control electrodes as a comparison spectrum with each sample spectrum in order to distinguish the sample material from electrode impurities. Graphite rods $\frac{1}{8}$ in. diameter and $\frac{3}{8}$ in. long with flat cut ends are appropriate. These should be purchased purified after machining, and should be handled with forceps so as to prevent any contamination.

Arcing—The electrode which holds the sample is placed in the bottom clamp at a gap distance of about 2 mm. from the upper counter electrode. There should be no pre-exposure, and the exposure should be short so that the electrode background is not excessive. The chips are consumed within a few seconds so that a total exposure of 10 sec. is adequate. The usual condensing lens and source-to-slit distance should be satisfactory. However, where alternate lens systems are readily available, the one possessing the greatest speed would be most desirable. A 2-amp. arc of either an alternating or direct current is appropriate. Current, voltage, and degree of regulation are apparently not critical for this purpose.

Spectra—Spectrum analysis No. 1 plates or film are usually employed, and the customary rapid processing procedure may be used. If an emulsion of greater sensitivity appears to be necessary, Eastman Type 103-0 should be tried. For wavelength comparison, a spectrum of iron adjacent to the sample spectrum is useful, since iron lines may be easily identified by means of available atlases. When the area drilled consists of an abnormality in an otherwise homogeneous

specimen of known composition, it is often desirable to have a spectrum of this surrounding material on the same film for comparison.

Since the full slit aperture of the spectrograph can be uniformly illuminated, it is possible to make microphotometer measurements on the spectral lines. When the sample contains high percentages of more than one element, it is possible to make semiquantitative determinations from microphotometer readings on the sample spectrum and corresponding readings on the spectra of comparison standards. Also, if sufficient sample is arced, it is possible to determine relatively minor constituents quantitatively by the microphotometering of minor constituent lines in comparison with a major constituent line. This procedure corresponds to the common internal reference line method.

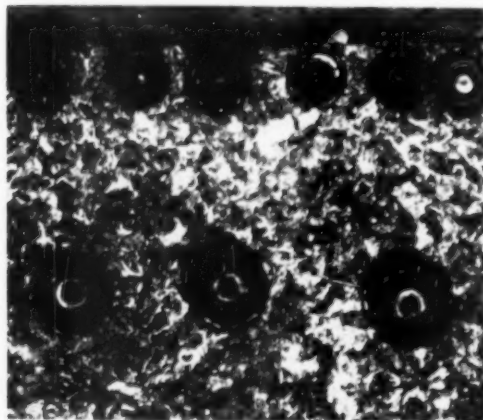
APPLICATIONS

This microdrilling technique can be applied to several classes of metallurgical problems. Metallic, and sometimes nonmetallic, inclusions can be identified in a matrix of normal material. A series of closely spaced samplings can provide evidence of segregation and identify segregates. Metallic constituents of individual crystals can be identified, providing the structure is not too fine. Underlying layers of multiple platings can be sampled and identified individually by drilling into their cross sections. By means of a series of drillings, one can sometimes determine diffusion characteristics of metals.

Figure 3 illustrates how a 0.003-in. plating was sampled by means of a 0.002-in. diameter drill to determine the purity of the plating. Copper, zinc, and cadmium were identified in addition to the major element, silver. Since the alloy was later found to contain only 15% Cu and 15% Zn, the procedure allowed the detection of approximately 0.1 microgram of each of these elements.

Another specific application is illustrated by Fig. 4. A specimen of 0.01% boron steel was sampled to compare the boron concentration along the edge with the concentration in the center of the section. Use of the microdrill made it possible to confine the sampling to within 0.005 in. of the edge. The method is sufficiently sensitive that the boron line from each set of drillings can be measured on a microphotometer and compared with an iron reference line for a quantitative determination.

Fig. 4—Samplings Taken From Boron Steel to Determine Relative Concentration of Boron at the Surface (0.003-In. Drill) as Compared With Concentration in Center of Specimen (0.005-In. Drill)



Measurement of Case Depth

By DALE J. WRIGHT, General Superintendent
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NUMEROUS methods are employed throughout industry to measure the depth of carburized cases on steel, largely because there is apparently no standardized procedure which is acceptable to all. Articles have been published describing various "approved" or "standard" procedures, but generally each company or industry has preferred to apply its own particular technique based on its own interpretation of case depth and the availability of either shop or laboratory equipment.

Until approximately seven years ago, the heat treating division of Caterpillar Tractor Co. encountered inconsistencies in case depths on test bars which were not always explainable. Each such instance involved considerable extra expense because of additional testing and destruction of piece parts. An analysis of the problem revealed that very often the fault was in the manner of determining case depth rather than in the carburizing operation. At that time, therefore, we set out to define the most applicable and economical manner of checking this metallurgical quality and standardizing accordingly. The objectives which would have to be met for our use were as follows:

1. Determinations must be accurate and repetitive. The method must eliminate differences of judgment between people making the determination, something we found to be the greatest problem in our previous practices.
2. Determinations must be made quickly so that "in process" heats can be checked at any time without delay.
3. The procedure must be simple so as not to demand highly skilled technicians, a requirement particularly important during week-end or holiday operation.
4. Equipment should be relatively inexpensive and durable, and cost of individual determinations be as low as possible. Importance of the latter consideration is attested by the fact that we average 250 determinations a day.

5. The method used should represent a measure of the control of the carburizing process, and not attempt to evaluate other variables such as material or design of the piece.

6. The determination should indicate a case depth which would find acceptance under a broad interpretation of the term "effective" depth of case.

A number of approaches were tried during the investigation for a method which would meet these requirements. Thus, test bars of carbon and alloy steels were etched or heat tinted to resolve the carburized case for its measurement with a special scale, Brinell or equivalent low-power magnifications in conjunction with appropriately calibrated lineal divisions were used to measure the case on fractured or polished and etched transverse sections.

Two other ideas studied were hardness tests on step-ground and tapered bars and transverse sections; and the microscopic examination of carburized, and of carburized and hardened bars which had been tempered at 1100° F. in cast iron borings.

In keeping with our stated objectives, we decided on a combination of the first two methods, regulated so as to control the known variables and made to conform easily with all of our needs. After many years of its use we are well pleased with the results, and confident that any troubles we may encounter are not due to the method of checking case depth.

The following describes the procedure we employ, which is actually very simple to apply after a brief initial instruction.

Description of Test Bars—Test bars are procured from a mill heat of known characteristics and in sufficient quantity to last a number of years. The cold finished bars are 7/16 in. square and 3½ in. long, and a hole is drilled near one end on those which require suspension in the furnace. Chemical composition of the bars is: 0.17 to 0.20 C, 0.80 to 0.90 Mn, 0.17 to 0.22 Si, 0.040 S, 0.020 P, 0.12 Ni, 0.08 Cr, 0.02 Mo, 0.05 Cu, 0.15 total Ni plus Cu; all but the first three are maximum values.

The A.S.T.M. grain size is No. 1 to 4, with a maximum spread of two numbers. The test bars are run with the production parts in every furnace charge and at regular frequent intervals on continuous furnaces. Test bars which have been checked for case depth in the manner to be described are used to accept or reject production material with which they have been carburized. Use of test bars of uniform carburizing characteristics is necessary in order to isolate the variable being checked to that of the carburizing routine itself.

Hardening of Test Bars—After cooling from carburizing to at least a "black" heat, bars

Instrument Eliminates Human Element

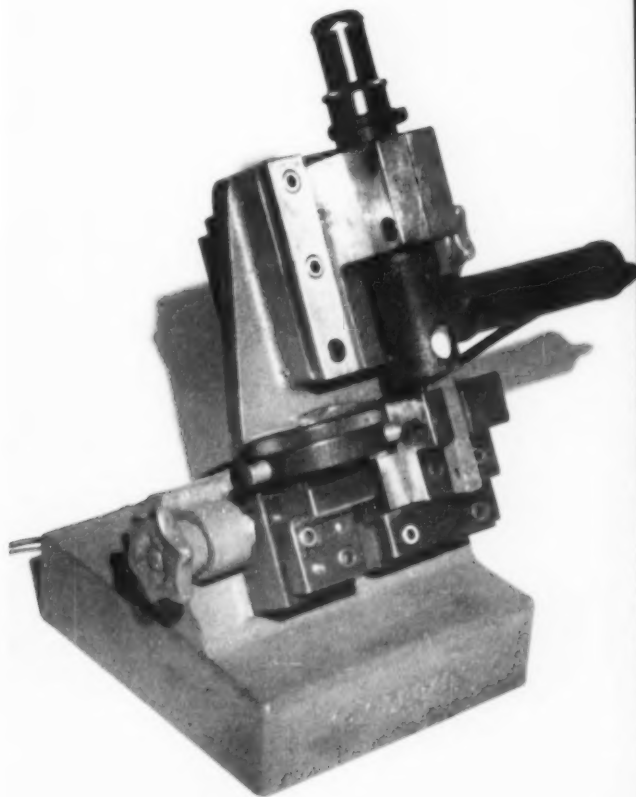
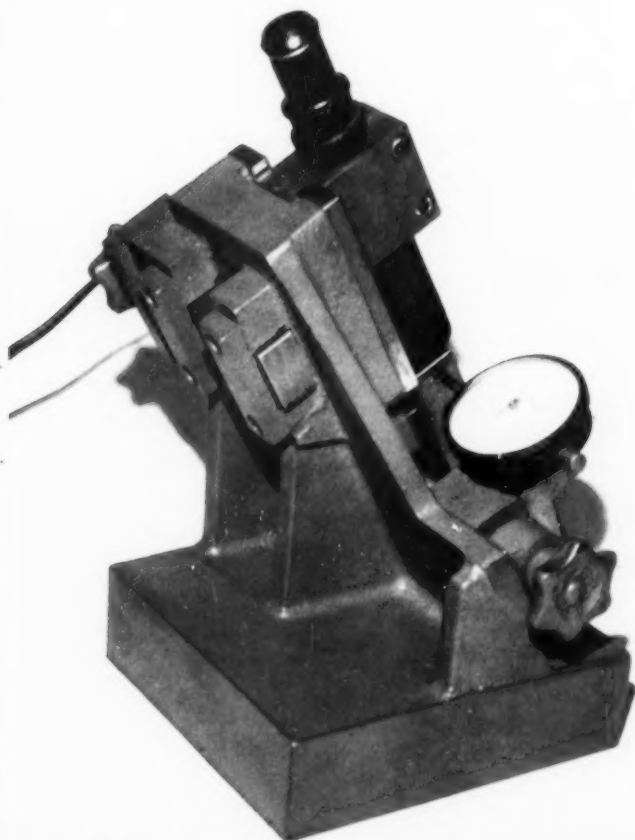
are loaded into a small Hevi-Duty electric furnace equipped with a circulating fan. Up to 20 pieces are loaded at one time in an alloy pan. This furnace is used for this work only and is maintained at 1440° F. \pm 5° F. at all times. Heating time is held to 22 min. \pm 30 sec., and no protective atmosphere is used. Test bars are then quenched until cold in a full flow of water at 75° F. \pm 5° F.

Fracturing and Etching—The bars are broken transversely at approximately their mid-point and etched in 10% nital for 8 sec. Care must be exercised to use fresh nital which has not been exposed to air for more than 2 hr. The etched fracture is rinsed in water and dried with compressed air, resulting in a clear, definite line of demarcation between case and core.

Reading Case Depth—The instrument we developed for determining depth is of a simple, inexpensive design, yet it has eliminated the difference between individuals making the determination and the natural inclination of people to "interpret" the case measurement as they may happen to see fit. The principal parts of this instrument are an illuminated Bausch & Lomb Brinell microscope (magnification 10 \times),

Fig. 1—Instrument Designed at Caterpillar Tractor Co. for Accurate Measurement of Case Depth. Principal parts consist of an illuminated Bausch and Lomb 10 \times Brinell microscope and a dial indicator mounted on a metal base. The case depth is read on the dial indicator

Fig. 2—Rear View of Measuring Instrument With a Test Bar in Place



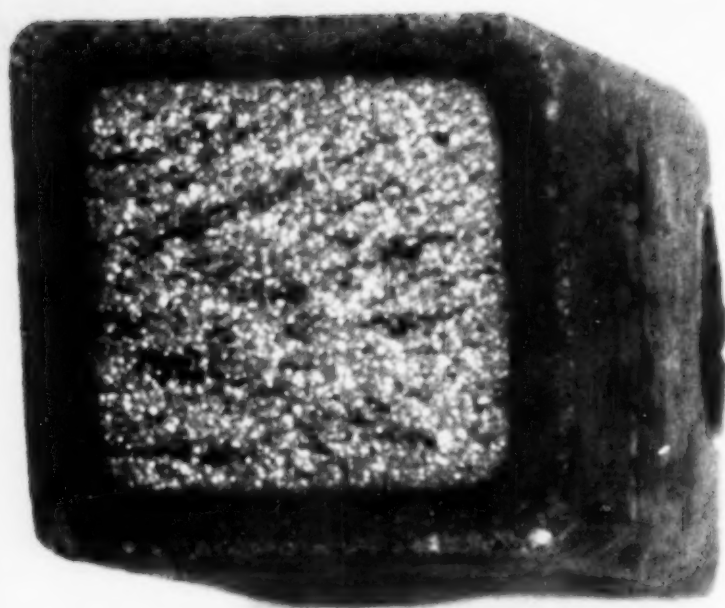


Fig. 3—End View of Test Bar After Being Fractured and Etched. The case depth is clearly defined by the darker portion; free ferrite is indicated by the light spots in the center portion. 10×

and a dial indicator mounted on a metal base. When the test bar is placed in the instrument, the hairline of the microscope is zeroed to its edge. The bar is moved so that the hairline coincides with the first free ferrite. The case depth is then read directly on the dial indicator.

From our investigational work it was found that a reading to the first grain of free ferrite would coincide closely with a 0.40% carbon con-

tent and a hardness of Rockwell C-50. On this instrument accuracy of repetitive readings, between individuals as well as between different readings by the same individual, is within 0.001 in.

Figure 3 (reproduced at the same magnification the operator receives in the instrument) clearly shows the darker case depth.

It is recognized that the methods described in this article could not be applied to all shops as a means of production control, because some equipment is necessary, although it is by no means elaborate or expensive. However, it is with some hope of standardization that this description has been prepared, since there certainly is a need in industry for closer measurement as well as uniformity

in methods employed. Perhaps variations from the foregoing would at least permit us all to "speak the same language" and make comparisons from the same basic beginning. If there were enough interest in standardization, it would not be difficult to make test bars and reading instruments available, just as standard methods and equipment for hardness measurements have been available for many years. ☛

Current Russian Metallurgical

IN CONTINUATION of the survey of contemporary Russian metallurgy, presented in the August 1951 and March 1953 issues of *Metal Progress*, five additional books published in the Soviet Union in the period 1947 to 1951 are here appraised. The first three are of special interest because they give a comprehensive and detailed description of both ferrous and nonferrous metals and alloys in production as of 1950-51. The other two are concerned with nonferrous industries, one extensively describing nickel and

copper (a few critical issues excepted) and the other dabbling with a number of the so-called "rare metals", including molybdenum, titanium and the transuranics.

SOVIET METALS AND ALLOYS

"Introduction to Metallurgy," by G. I. Pogodin-Alekseev, Yu. A. Geller and A. G. Rakhshadt; Governmental Publication for the War Industry, Moscow, 1950, 455 p.

Two Books on Corrosion

In considerable contrast to the usual "introductory" texts, this book contains information placing it in a class by itself. One of the better examples that might be mustered by a proponent of socialized science, it sets forth Soviet metallurgy from the organized viewpoint of a singular government-backed program. Significantly, the book is published by a governmental branch called the War Industry (more euphemistically named the "Ministry of Defense" in other countries), and its purpose is to serve as a uniform instruction on the properties and applications of standard metals and their alloys.

Even the introductory chapter is vigorous, compressing much information in brief compass. It is a history of Russian metallurgy beginning with Anasov in 1831, ending with Bochvar in 1947, and carrying 11 portraits of such distinguished investigators as Anasov, Tschernoff, Belyaev, Kurnakov, Baboshin, Shteinberg, and Bochvar—most of these also pretty well known to western scientists.

The remainder of the book is divided in six sections, plus an extensive appendix. The seven chapters of the first section describe methods for studying metals; binary and ternary diagrams are the subject of the second section; the third discusses plastic deformation and recrystallization; the next two treat the structure, properties, and heat treatment of both ferrous and nonferrous metals and alloys; and the sixth section closes with instructions for selecting the proper alloy and suitable heat treatment for a wide range of industrial and commercial applications.

Threaded throughout the entire text are 515

exemplary problems, designed to teach the students how to interpret the given theories and reduce them to practice.

The 56-page appendix lists by "mark", composition, and application all standardized metals and alloys used in the Soviet as of 1950—iron, steel, cast iron, copper-base alloys, aluminum-base alloys, magnesium alloys, bearing metals and babbitts, the hard metals (WC-TiC-Co combinations), and many others. The book offers an outstanding opportunity for comparing Russian and American ferrous and non-ferrous practice.

"Metals and Alloys in Chemical Machine and Apparatus Construction," by D. O. Slavin and E. B. Shteiman; Government Scientific-Technical Publishing House, Moscow, 1951, 463 p.

In the preceding text, the Soviet standards are presented principally from the viewpoint of mechanical properties, whereas this second volume treats the same broad field principally from the standpoint of corrosion resistance. The two thus complement one another.

Introductory chapters contain many tabulations of corrosion measurements, based upon a "ball scale" rating of 1 to 10 covering 0.04 to 400 mils penetration per year. Electropolishing is discussed, a phosphoric acid electrolyte being recommended. There are charts for grain size, inclusion count, and graphite standards, this last with a discussion of spheroidal cast iron which appears in a Russian book for the first time, to this reviewer's knowledge.

As in Pogodin's text, a virtually complete listing of Soviet metals and alloys is given. A few differences between the two listings are apparently the result of a rapidly changing and improving system of codification, especially noticeable for high-alloy and stainless steels.

"Corrosion of Chemical Apparatus and Corrosion Resistant Materials," by I. Ya. Klinov; Government Scientific-Technical Publishing House, Moscow, 1950, 291 p.

Although similar to the two preceding books, this text is inferior in both scope and detail. It specifically concerns special alloys designed for corrosion resistance, both in liquid mediums at ordinary temperatures and in active atmospheres at elevated temperatures. The treatment is at best mediocre—often either careless or uninformed—although some material can be found which supplements that in the other Russian texts.

Texts—III



By CARL ANDREW ZAPFFE
Consulting Metallurgist
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Nonferrous Metals and Alloys

In the works of Slavin and of Pogodin-Alekseev and co-authors, the Soviet program for nonferrous metals and alloys is comprehensively outlined, whereas the two volumes next to be described treat certain of the nonferrous fields in more detail.

"The Metallurgy of Copper and Nickel," by V. I. Smirnov, Government Scientific-Technical Publishing House, Moscow, 1950, 591 p.

"In foreign countries the nickel industry provides a typical example from the Capitalistic Industrial Epoch of Imperialism and World Wars. Its growth proceeds irregularly, expressing those inevitable crises and depressions which step by step lead to the monopolizing of production."

Thus Smirnov comments upon the non-Soviet nickel industry in a brief introduction to what is otherwise an excellent technological discussion. His book is in two parts, one on copper, the other on nickel.

The Russian nickel industry is defined as entirely post-Revolution, except for primitive operations conducted in the Urals prior to 1917. An All-Soviet Conference for Nonferrous Metals was held early in Stalin's regime, and a plan was proposed for an organized nickel production based upon the Ufaleiski deposits in the Urals. By the time of the second conference, a specific program was formulated, using nickel oxide ores and bessemer matte. Later geological discoveries, in combination with the establishment of the Ufaleiski plants, led to a much broadened development which now includes a special institute for the study of nickel and related problems. Smirnov points to the present nickel industry as a proud example of Russian science and economy.

As for copper, he states that Russian production declined so badly during World War I that by 1918 it had virtually ceased. A tabulation of world production of cast copper is given, significantly subtitled "except U.S.S.R." A search of the text discloses only the indirect information that Soviet production during World War II was "many times greater" than in pre-Revolution years, and that the quota of the 1946-50 Five-Year Plan was exceeded by 160%. The total supply of copper in the various deposits of the world at the present time is estimated at 100 to 120 million tons, approximately 80% being in the U.S.S.R., Chile, Africa, and the U.S.A. Perhaps this can be interpolated by an expert to give a figure for Russian copper.

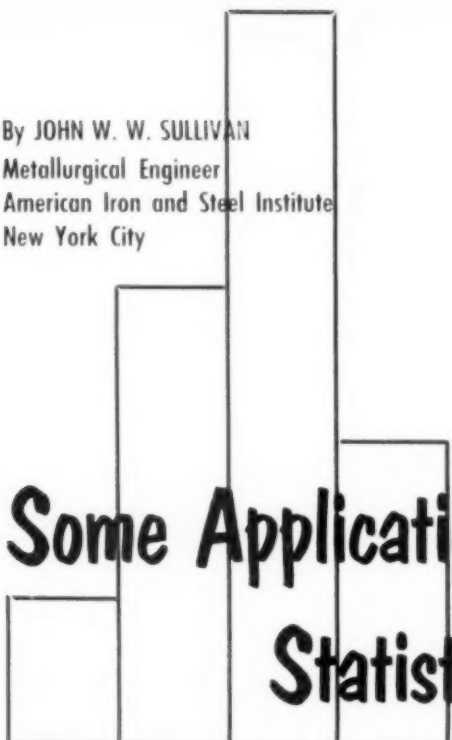
Smirnov states that Russia has rich deposits of copper ore in the Urals, Caucasus, and Siberia, and he names seven plants that have been built, but only for the period 1922 to 1931. Their augmented copper production is largely the result of the huge electrification program begun by Lenin at the Party's Annual Conference IX and culminated in Plan GOELRO. A significant part of Russian ores is porphyritic, but the carbonates malachite and azurite are also included, as well as the sulphides chalcocite, chalcopyrite, and bornite. Copper concentrates, Smirnov states, have been widely used since the first Five-Year Plan and today approximately 75% of Russian production is based upon concentrates.

Except for his careful omission of Russian production statistics, Smirnov makes free use of melting logs, balance sheets, heat calculations, and even photographs of Russian operations. No physical metallurgy is included, but as a treatment of process metallurgy for copper and nickel the book is above average.

"Rare Metals," by O. A. Songina, Government Scientific-Technical Publishing House, Moscow, 1951, 259 p.

One of the leanest of the texts yet reviewed—considering the opportunities offered by the subject of rare metals—Songina's volume is obviously a victim of wartime secrecy. Nine chapters treat W, Mo, V, Re, Nb, Ta, Ti, Zr, Hf, U, Th, Ce, Ga, In, Tl, Ge, Be, Li, Rb, and Cs in that order. The coverage is methodical, each chapter beginning with a more or less acceptable history, followed by discussions of physical and chemical properties, applications, minerals and ores, economics, extraction, production, and analysis. There are 219 references in a bibliography which has some internationalism, although the section on molybdenum, for example, is entirely Russian. A worth-while contribution is the section on beryllium, which discloses that beryl is the abundant and the principal beryllium ore used in Russia, and that electrolysis of fused chlorides is their accepted method of extraction—in contrast to American practice based on magnesium reduction of the fluoride. The Russian technology is given in detail. The chapter on uranium, as a contrasting example of barren sort, includes only an elementary description of nuclear processes and the production of transuranic elements up to californium, No. 98. Little is given on physical metallurgy in this book, attention being rather on the chemical technology of extraction, production and analysis.

By JOHN W. W. SULLIVAN
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Some Applications of Statistical Analysis in the Steel Industry

IN THE PREVIOUS three lectures in the Philadelphia Chapter's educational course on "Practical Applications of Statistics in Laboratory and Production" (published serially in *Metal Progress* since the September issue), Dr. Youden has already told how to measure the variations which exist in any group of ostensibly identical items caused by minor deviations in the materials, measurements and the measurers; next Professor Burr gave a brief account of methods, based on the mathematical theory of probabilities, of analyzing the data acquired from inspection and testing and for drawing useful conclusions therefrom; and then Mr. Hood outlined briefly ten ways wherein statistical methods are being used by the Aluminum Co. of America to help make a product of uniform and high enough quality to meet the requirements of use at the lowest possible cost.

In this, the final lecture, the control of variability in steel technology, on the basis of information revealed by statistical methods, will be discussed briefly by citing three case his-

ories from many which are available. The wording of the last sentence has been chosen to emphasize the fact that statistical methods, by themselves, cannot control variability in steel technology. Statistical methods merely reveal significant numerical relationships, involving comparisons with standards. The actual control of variability is then accomplished by doing something or refraining from doing something to the raw materials, manufacturing operations and production personnel.

Variability is always present in manufacturing. No process, however skillfully controlled, can produce identical articles—that is to say,

articles which cannot be distinguished from one another by measuring their properties.

A typical example of variability in the manufacture of alloy steel is shown in the black line of Fig. 1, already used by Professor Burr. It summarizes data from 331 heats of 4032 H steel (hardness of the Jominy bar, 1/16 in. from the quenched end). The smooth, bell-shaped curve superimposed in color is variously called the "normal curve", the "curve of error", the "probability curve" or the "population distribution", but by whatever name it is the limit that is approached by plotting a very large number of observations (or values of a variable). Its significance has been expounded in the previous lectures in this series; here it may be observed that statistical analysis of a limited set of data depends on the differences between the distribution of data from the sample and the normal probability curve.

The shape of the normal curve implies the following propositions, all of which have been verified experimentally:

Sources of Variability

1. Small deviations occur more frequently than large ones. This is mathematically verified by the fact that the curve has a maximum at the mean value.

2. Very large deviations are unlikely to occur since the curve is asymptotic with the X axis.

3. Positive and negative deviations of the same numerical magnitude are equally likely to occur since the curve is symmetrical with respect to the mean value.

The magnitude of the variation, together with the frequency or number of occurrences of variation (of the property values of successively produced articles) from particular or specified values, is what we are trying to control. Such variations in the finished articles, it is worthy of repeating, are due to

1. Variability in the raw materials used.
2. Variability in manufacturing operations.
3. Variability in the operating personnel.

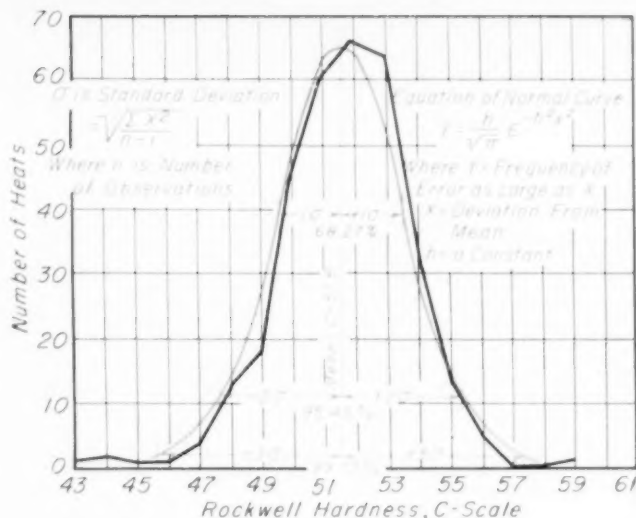
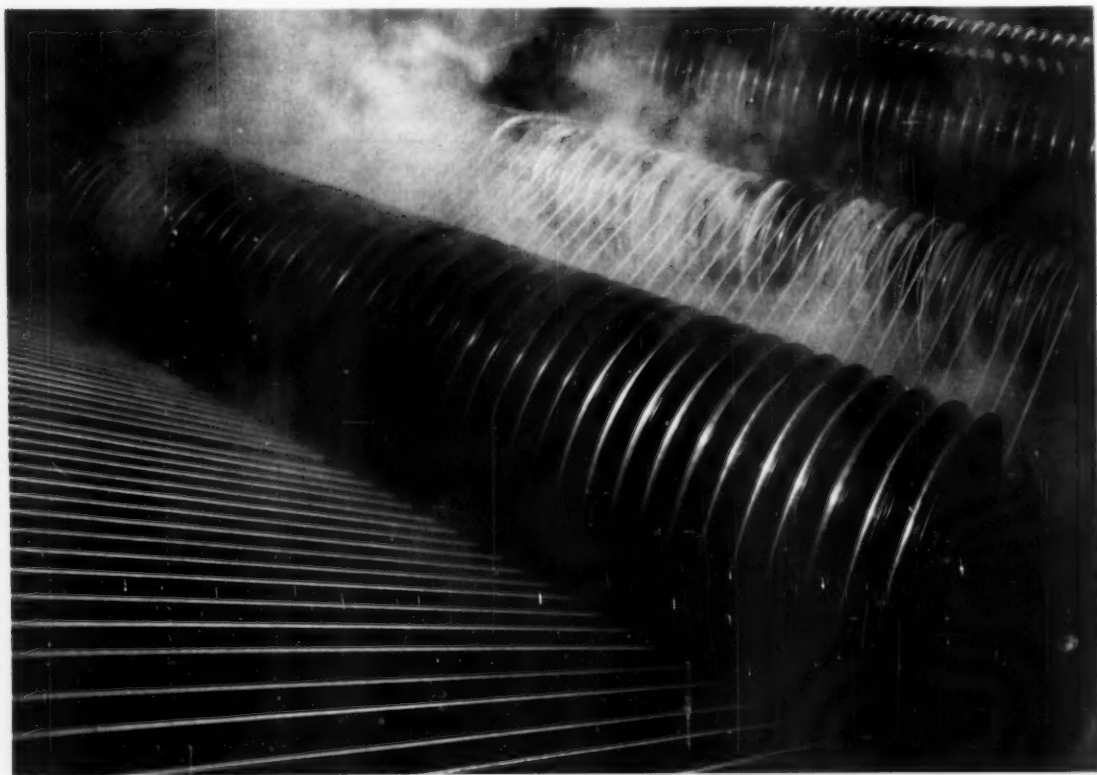


Fig. 1 — Frequency Polygon (Black Line) for Data on Hardness of 331 Heats of 4032 H Steel and (in Color) Normal Probability Curve for Indefinitely Large Number of Tests Which Would Have the Same Mean (51.6) and the Same Standard Deviation (2.08)

Fig. 2 — Exit End of 40-Wire Galvanizing Installation, Showing Sheaves Which Are Used for Carrying the Hot Wire Through a Water Quench. (Photograph courtesy of Republic Steel Corp.)



Let us now pass from these general and qualitative statements to some specific and quantitative case histories:

COATING ON GALVANIZED WIRE

Control of coating weight of hot-dipped galvanized steel wire by the aid of charts for "average" and "range" is an outstanding example of manufacturing variability control. Use of those charts resulted in a saving of 11.8% of zinc, with favorable prospects for more.

The problem concerned a 40-wire, hot-dip galvanizing unit in which steel wire in diameters of 0.072 to 0.162 in. can be coated with a specified minimum of 0.50 to 0.80 oz. of zinc per sq.ft. of surface. How should the process be operated to assure coatings of at least the specification minimum weight with a least consumption of zinc—that is to say, with the least surplus over the requirement? Incidentally, it required accurate measurements to 0.01 oz. per sq.ft., which, in terms of thickness of zinc coating is extremely thin—namely, 17 millionths of an inch.

Variations were measured by the first units described by Dr. Youden in the September 1953 issue of *Metal Progress*, namely "average" and "range". (The charts and methods are completely described on p. 290 to 320 of Walter A. Shewhart's book "Economic Control of Quality of Manufactured Product", published by Van Nostrand, New York, in 1931, and in the A.S.T.M.'s "Manual on Presentation of Data", 1940, p. 47 to 66.) Briefly stated, controlling the average and the range of variability is based on the concept that a process is in "statistical control"—with respect to a particular property of the process or the product—when the property values are within the control limits on the charts. The control limits are related to the range of variability that can be expected when no significant changes occur in the raw materials, manufacturing operations and operating workmen; theoretically, the variability in the process and the product is then due solely to chance and consequently the range of variability is predictable.

Control Charts for Galvanizing

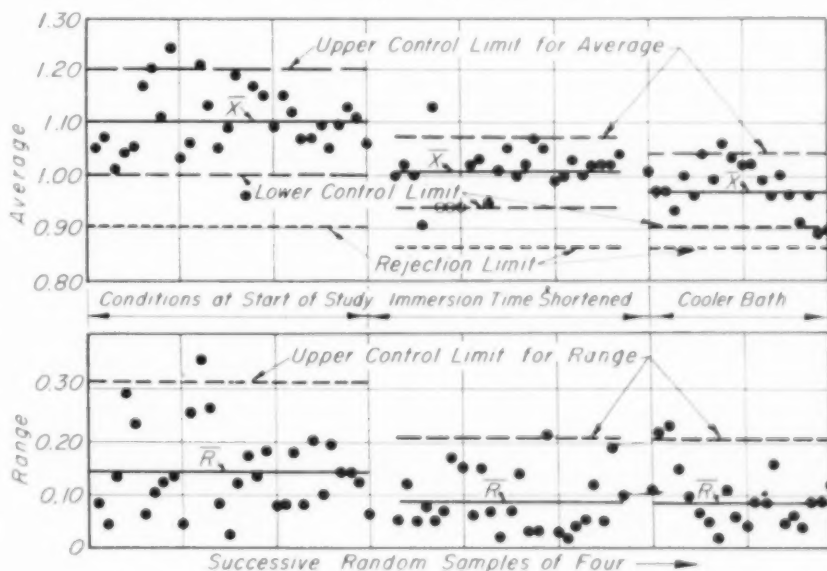
When property values are observed which are *outside* the predicted range, the probability that they resulted from a process in statistical control (as well as the probability that they resulted from a process *not* in statistical control) can be computed. Those probabilities are the primary guides in deciding whether or not a variation in a property value from a predetermined reference value or standard is an important variation which necessitates a change in the process, or, on the contrary, is an unimportant variation not requiring a change to maintain the process within the desired control limits.

The charts for average and range of coating weight of galvanized wire, which we are about to discuss in detail, are shown in Fig. 3.

The left portion of Fig. 3 shows two control charts during the first stage of the investigation, the upper being the chart for average coating weight and the lower the chart for range of the coating weights.

The chart for average was prepared in the following manner: Four of the 40 galvanized wires were selected at random to provide a sample of four pieces, and the weight of the zinc coating on each was determined in oz. per sq.ft. The average of the four results was plotted as a single dot on the upper chart. Periodically, successive samples of four pieces each were taken, the coating weights determined and averaged,

Fig. 3—Control Charts for Average Weight of Zinc Coating on Hot-Dip Galvanized Wire, and for Range of Weight. Size 0.105-in. extra galvanized wire, specified to have 0.80 oz. per sq.ft. minimum of zinc



Thinner Zinc Coatings Possible

and the average plotted in succession. After the production of a predetermined amount of wire, and the plotting of a predetermined number of averages of coating weights, the arithmetical average of the averages was computed. It turned out to be 1.10 oz. per sq.ft., and this is represented by \bar{x} , the central horizontal line in the upper chart in Fig. 3.

The dashed horizontal lines in the left portion of the top chart are the upper control limit for average (UCL) and the lower control limit for average (LCL) respectively, and their values are computed to be 1.20 and 1.00 oz. per sq.ft. from the formulas

$$UCL = \bar{x} + c \bar{R}$$

$$LCL = \bar{x} - c \bar{R}$$

where \bar{x} is the grand average (average of the individual averages) and \bar{R} is the average of the individual ranges shown in Fig. 3 and c is a constant depending on sample size, being 0.729 for a sample of four.

The range of variability in coating weight, plotted in the lower part of the chart, is numerically equal to the difference between the maximum and minimum of each sample of four. That range is plotted for each of the samples, directly below the corresponding plotted value for the average. The average range, \bar{R} , obtained by summing the range values and dividing by the number of samples, is plotted as the central line in the lower chart. The upper control limit for range is computed by multiplying the average range by a constant which depends upon the sample size. For a sample size of four the constant is 2.28. The lower control limit for range is plotted only when the sample size exceeds six, because the lower control limit is zero for sample sizes of six or less. In the left portion of the lower chart in Fig. 3 the average of the range is 0.138 oz. per sq.ft., and the upper control limit for range is 0.314 oz. per sq.ft.

The 30 values plotted in the left portion of Fig. 3, although limited in number, suggest that the process is practically in statistical control—that is, the variability in the weight of the zinc coating as expressed by the control limits is the result of chance variations in the process. However, the grand average (\bar{x} = 1.10 oz. per sq.ft.) is higher than is desired for a specification minimum of 0.80 oz. per sq.ft. Consequently, a change was made in the process that was intended to lower the grand average and yet control the variability so that the specified mini-

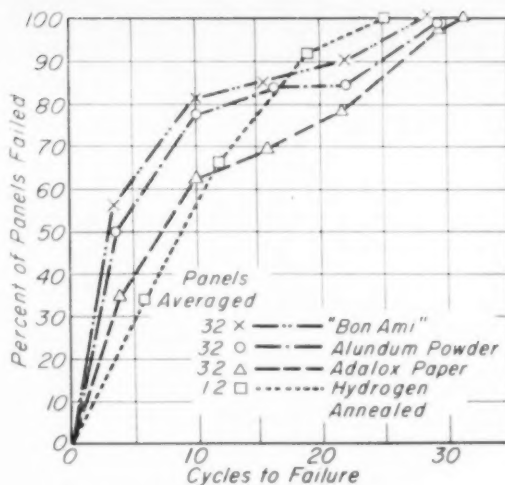


Fig. 4—Preliminary Tests on Oiled Sheet Steel in Humidity Cabinet, Operated Cyclically, Show Uncontrolled Variability in Test Conditions. Since "Cycles to Failure" Vary by More Than 100%

um would be met. That change was a decrease in the time of the immersion of the wire in molten zinc. Actually, that change involved two variables—the length of the immersion and the speed of the wire—since neither could be changed independently because they are both related to the mechanical properties of the wire and to the properties of the coating. Both were changed in such a manner as to reduce the immersion time and not significantly change the mechanical properties. The results of that change in practice are shown in the center portion of Fig. 3.

Two improvements resulted—a reduction in the grand average from 1.10 to 1.007 oz. per sq.ft. and a reduction in the variability, as expressed by the difference in the control limits for average, from 0.20 to 0.133 oz. per sq.ft.

At this point the metallurgist responsible for the development of the control charts decided to make another change in the process to reduce further the consumption of zinc and still produce an acceptable product. The bath temperature was lowered with results shown in the right portion of Fig. 3.

The grand average, or "level" of the process, was lowered to 0.97 oz. per sq.ft. The variability (difference between upper and lower control limits) remained about the same, namely 0.14. At this point it was found that the process was operating at a saving of 11.8% of the zinc and was producing an acceptable product.

Although the specification minimum of 0.80 is appreciably below the lower control limit of

Testing Rust-Protective Oil

0.90, a "modified lower control limit" of 0.87 oz. per sq.ft. was drawn on the upper chart in the right portion of Fig. 3 as a rejection limit. That limit corresponds to the specification minimum plus half the allowable deviation of the averages.

Other data, not shown in this case history, suggest that there is at least one additional variable which affects the coating weight, and a search for that variable is now in progress, so that even greater saving in zinc may result from the use of the foregoing control chart method of controlling variability.*

A STUDY OF A TEST METHOD

Protection of steel from rusting while in transit to a fabricating plant or warehouse is currently under investigation by the Technical Committee on Protective Coatings of the American Iron and Steel Institute by accelerated testing of steel panels coated with protective oils. Such a test program involves a study of the variable protection offered by specific oils, and is complicated at least by two additional sources of variability, namely, the testing apparatus itself and the steel surface immediately prior to coating.

The testing apparatus is essentially a humidity cabinet in which the humidity, temperature, flow of air, cleanliness of the air and inertness of specimen holders are controlled to a degree believed to be adequate. However, the cabinet exhibited variability traceable to at least one cause, the position of the specimens in the cabinet, and possibly to other causes.

At the start of the investigation, steel panels were cut from one grade of sheet steel having a particular and reproducible surface finish, made to conventional standards. This finish was believed to be sufficiently uniform to rule out any significant variability from that source, but it turned out to be insufficiently uniform, possibly because of variability occurring in the superficial oxide film.

The initial search for a method of providing a uniform steel surface, to rule out the surface as a significant source of variability, was disappointing. Figure 4 shows the results of polishing the steel surface with various abrasives and also the results of reducing the oxide coating by hydrogen.

For each type of finish the number of humidity cycles to failure of a given oil film varied from less than 10 to more than 20, or a difference of more than 100%, despite efforts to control every other known source of variability. However, the search continues, and the latest reports

on the development of a new surface treatment are encouraging.

Another important factor in this investigation turned out to be a method of applying the protective oil so as to yield a uniform and reproducible film having a closely controlled thickness. It was found that apparently identical oil films behaved differently, possibly because polar compounds in the oil were not uniformly distributed throughout the film or did not uniformly cling to the surface of the panels.

Thus, the test results are a summation or integration of all of the sources of variability (both known and unknown) in the testing of the oils. Fortunately, however, statistical methods known as "variance analysis" are now being used to separate known sources of variability from each other. This statistical method of evaluation involves the calculation of the standard errors of successive runs and of the differences between means, and also the testing of those differences for significance.

When the statistical analysis is completed it is likely that quantitative explanations will be available to account at least for some of the known sources of variability.[†] Of greater importance, however, will be some quantitative measure of the range of variability of test results that can be attributed to the oil protective coatings themselves, independently of other sources of variability. In this way, it is expected that ultimately the accelerated testing of the coatings can be placed on a more reliable basis.

Problems of the foregoing type, involving complex interactions of causes of variability, can be successfully analyzed today only by statistical methods. This matter was discussed in some

*In the discussion, a questioner raised the point that "in the inspection of a coil of wire for defects there is not a coil at the finish but several pieces". However, a coiled wire has two ends. If it is a matter of dimensional control, a measurement of both ends usually gives satisfactory assurance as to the dimensions throughout the length of the coil. By checking the diameter of the wire at periodic intervals, changes in dimension resulting from tool wear can be detected so that it is possible to control the process without the necessity for destroying individual coils. There may be intermittent defects throughout a coil of wire — or for that matter in a coil of sheet or a coil of foil — which cannot be detected by inspection of the ends. Necessarily reliance must then be placed on either the inspection of a great many ends of the product, or intermediate inspection during the final shearing or coiling operations, or by correlating the results obtained in subsequent operations in the customer's plant where the material is cut into smaller pieces.

†See "Analysis of Variability in Accelerated Corrosion Testing Cabinets", by V. V. Kendall, *Yearbook of the American Iron and Steel Institute*, 1953.

Determination of Hardenability Bands

detail by Professor Burr in his lecture published in October's *Metal Progress*.*

In view of the widespread use in America of alloy steels purchased to hardenability limits as measured by the Jominy end-quench test, it may be of more than ordinary interest to review the manner in which statistical studies have aided in fixing the commercial limits in existing specifications. This brief account will concern the steel used during the war and designated as 4032 H with approximately 0.25% molybdenum. It is a carburizing steel, used for transmission

plant — to say nothing of the wide variability in scrap, fuel and other materials in the furnaces owing to geographical location of the plants.

Establishment of specified limits is desirable because a single consumer demands from several producers the identical steel so far as hardenability limits are concerned. The consumer wants identical steel from various sources so that he does not have to vary his heat treating medium and procedure. In effect, the steel producers aid the consumer by providing a narrow range of hardenability variability.

Prior to the 1930-1940 decade the word "hardenability" was usable only in a qualitative sense.



John W. W. Sullivan, since 1945 with the technical staff of the American Iron and Steel Institute, and now its metallurgical engineer in New York City, has held positions as research engineer with A. O. Smith Corp. in Milwaukee, and a similar post with the American Steel & Wire Co. in Cleveland. During World War II he was chief of inspection for the Cleveland Ordnance District. He has also written on science subjects for the Cleveland Plain Dealer, and is the author of the book's best selling techbook "The Story of Metals". Among others, he is a member of the American Society for Metals, the American Institute of Mining and Metallurgical Engineers, the American Society for Quality Control, and the American Statistical Association.

gears and pinions for passenger automobiles, and light gears for trucks.

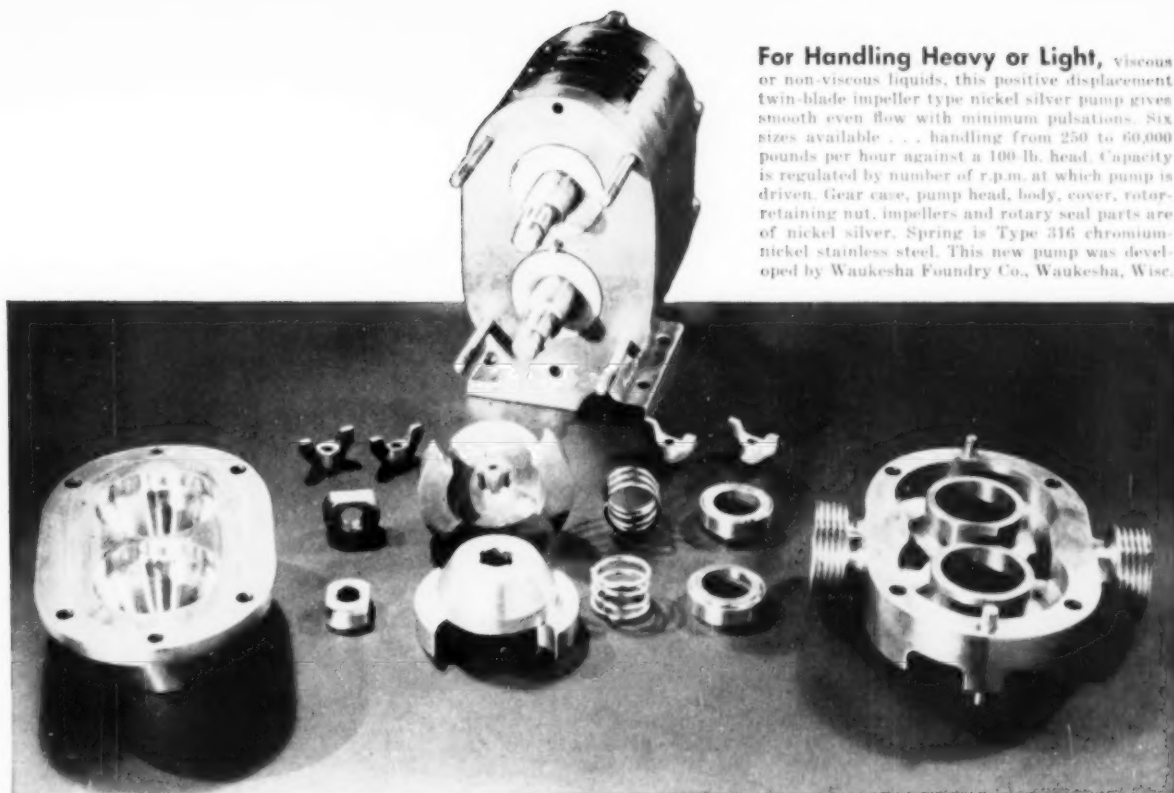
The statistical phase of the problem confronting the steel industry was to determine the hardness limits narrow enough so the steel could be heat treated to a satisfactorily uniform product in mass production, and also be within the economical limits of manufacture — despite the variability in steelmaking practices that existed from company to company, plant to plant within a company, and furnace to furnace within a

Since then quantitative bases have been established from the work of the late Marcus A. Grossmann and of W. E. Jominy and A. L. Boegehold. That work is so well known to members of the American Society for Metals that it would be superfluous to outline its nature and great influence on modern steel treatment. Suffice it to say that prior to their studies the steel industry and its demanding customers attempted to control hardenability by narrowing the ranges for the individual elements in the steel.

*A shrewd way of applying "variance analysis" was quoted from a scheme used by Richard Ede of the Gary plant of U. S. Steel Corp. His technique may be illustrated from a study of the effect of composition on a certain property of steel. Assuming the sulphur content is an important factor and that it is slightly "out of control", the midpoint of all the sulphur figures is determined. About half the heats of this type will have sulphur higher than this value, and

half will be lower, but the data themselves will set that point. Then he'll say it's "high sulphur" above this point, and "low sulphur" below it. (Or one can break up all the sulphur data that you have on, say 706 heats, into three parts substantially equal.) Then he'll do the same thing with manganese, thus getting two or three levels of manganese — again, letting the data decide where the group is subdivided. Then he does the same thing with the third factor. That

gives him roughly the same number of measurements in each cell, or at least a fair number in each. Then what he does is find out which cell has the least number in it, and pick at random that many from all the data you have for each of the rest of the cells. That gives a "factorial design", and is an automatic way of taking these heterogeneous industrial data from observers' records and putting them together to make a good analysis in a very little time.



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NEW YORK 5, N.Y.

Aluminum Sand Casting Alloys

Compositions, Properties, and Designations of American Commercial Alloys

Compiled by F. M. Howell, Aluminum Co. of America, and J. S. Jeralick, University of Minnesota, November 1953, from handbooks and specifications of the principal manufacturers, the American Society for Testing Materials and the Society of Automotive Engineers.

Designations			Composition (Balance is Aluminum)					Condition		Tensile Strength (ksi)		Yield Strength (ksi)		Elonga- tion % in 2 in.		Brinell Hardness		Shear Strength (a)		Fatigue Limit (a, c)		Fluidity (d)		Resistance to Hot Cracking (d)		Corrosion (Resistance) (d, m)		Machinability (d)		Welding (d)		Characteristics and Uses																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
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* Aluminum Co. of America alloy numbers. Heat treated alloys designated by letter T and heat treatment number after alloy number.

(a) In thousands of pounds per square inch.

(b) Minimum values.

(c) 500 million cycles in reverse bending using R. R. Moore machine and specimen.

(d) Relative rating; A = best.

(e) Not required. Experimental error comparable with values being measured.

(f) When below 1% elongation.

(g) Less than 0.5%.

(h) After standing at room temperature for several weeks the properties will approach those of the T 6 condition.

(i) From tests made approximately 30 days after casting.

(j) Based on tests made 5 to 7 days after casting.

(k) Relative corrosion resistance, as in marine exposure.

(l) Solution heat treatment involves soaking at high temperature followed by quenching.

(m) Solution heat treatment followed by artificial aging above room temperature.



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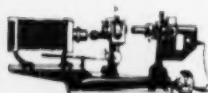
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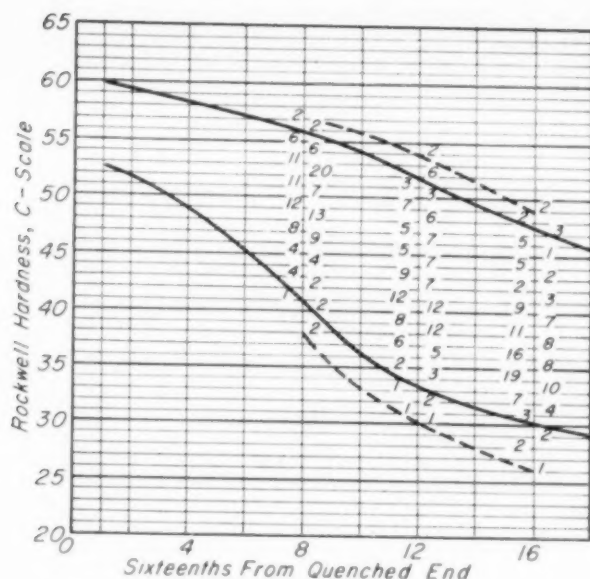


Fig. 5—Distribution of Hardness Readings on Jominy End-Quench Bars From 126 Heats of 3140 H at 8, 12 and 16 Sixteenths From the Quenched End. About 7% of the heats fall outside the accepted band

such as carbon, manganese, nickel, chromium and molybdenum, and this resulted in A.I.S.I.-S.A.E. specifications for alloy steel having very narrow ranges in composition. Such narrow ranges were not the solution of the problem because studies made in 1943 and again in 1946 and 1947 revealed that 14 to 16% of the open-hearth alloy steel fell outside the established standard chemical ranges, yet many of these out-of-specification heats were accepted upon submission to the user and performed satisfactorily. Narrow limits did not control the hardenability, nor did supplementary requirements such as grain size limitations, tensile properties, special hardening tests and others which were added to some customers' specifications. How this situation was corrected by the use of end-quench tests and hardenability bands permitting considerably wider chemical limits is considered at some length in a paper entitled "Standard Steels and H-Band Steels" by D. H. Ruhnke, E. T. Walton and P. R. Wray before the 1948 regional technical meetings of the American Iron and Steel Institute.

The first published hardenability bands were established with the aid of a calculation method suggested by Grossmann and were converted to hardness curves. The band within the curves included approximately 93% of the hardness results, and the curves were adjusted by comparison with actual end-quench tests from production heats. Because of occasional deviations from

Wider Bands Based on Statistics

reality in calculating hardenability from chemical composition and grain size, hardenability bands established since 1947 are based on statistical studies of actual end-quench hardenability tests from hundreds of production heats. An early example is Fig. 5, which shows a portion of the hardenability band for 3140 H.

The numbers listed vertically through the band show the number of heats whose hardness corresponded to that particular ordinate, and they comprise the hardness distribution at a particular distance from the quenched end. The curves defining the band were drawn after approximately 3% of the heats having the highest hardenability and a like percentage having the lowest hardenability were discarded. In this way the user is protected from receiving the occasional heat of steel that might crack on account of excessive hardenability and also on account of the occasional heat so low in hardenability that the steel might not harden properly or might require special processing.

A much better way of appraising an observed hardness distribution is illustrated in the data of Table I, taken from that used in 1950 for establishing the hardenability band limits for grade 4032 H and derived from end-quench hardenability tests of 331 heats.

Since these figures, representing hardness values at 1/16 in. from the quenched end of the specimen, have been analyzed previously in Professor Burr's lecture (*Metal Progress*, September), and the analysis summarized in Fig. 1, p. 92 of the present article, it need only be repeated that the mean value is hardness 51.65 and the standard deviation (a measure of the variability) is 2.08 units. The actual range of observed values at this particular location in the test piece is from a low of C-43 to a high of C-59, or 16 units.

Nearly all of the total area under the normal curve (the curve in color in Fig. 1) lies between the limits of the average plus and minus three standard deviations, the precise amount being 99.73% to the fourth significant figure. This is an important statistical concept because it means that 99.73% of the values should lie between the limits of plus and minus three standard deviations from the average, provided the manufacturing process is under control,

Plotting Impurity Effects

Hence, if any values lie beyond those limits the theoretical chance of those values occurring when the process is in control is only 27 in 10,000 or approximately 3 in 1000; conversely, the chances are great that such values result from a process out of control.

Applying the foregoing statistical concept to the Rockwell C-scale hardness obtained at a distance of 1/16 in. from the quenched end of the specimen for the 331 heats of grade 4032 H, we find that the limits of the average plus and minus three standard deviations are 45.41 to 57.89. Within those limits there are 327 hardness values, or 98.8% of the heats. Only four heats out of 331 are outside those limits. In view of the theoretical percentage of 99.73 it would appear that the manufacturing process is in control or extremely close.

To provide a margin of safety, for heats that may be slightly too high or too low in hardenability, the hardenability limits for grade 4032 H were set inside the three standard deviations at 48 and 55.5. This corresponds to a range of approximately plus and minus two standard deviations from the arithmetical mean.

The limits 48 to 55.5 embrace 316 heats or 95.5% of the total. The theoretical percentage of values within the average plus and minus two standard deviations is 95.45. This does not necessarily mean that the entire band including all distances from the quenched end of the specimen was established on this basis, but it does indicate that the quality of the product is assured in any manufacturing process, when the variability can be consistently and economically controlled at levels within those of the average plus and minus three standard deviations.

The foregoing case history (and others) certifies to the fact that the properties of a particular grade of steel produced by different companies are so uniform that the steels are interchangeable in use and are often indistinguishable by ordinary laboratory tests.

Incidental Impurities—Sometimes an almost impossible set of variables can be handled by subdividing the lot into manageable groups. An example is a study of the effect of ten incidental elements on the properties of carbon

Table I—Quenched Hardness of 331 Heats of 4032H and Computation of Variability (Sullivan)

ROCKWELL HARDNESS	NUMBER OF HEATS	DIFFERENCE FROM MEAN	$n \times^2$
C-59	1	+7.4	$1 \times 7.4^2 = 54.76$
58	0	—	—
57	0	—	—
56	5	+4.4	$5 \times 4.4^2 = 96.80$
55	14	+3.4	$14 \times 3.4^2 = 161.84$
54	34	+2.4	$34 \times 2.4^2 = 195.84$
53	64	+1.4	$64 \times 1.4^2 = 125.44$
52	66	+0.4	$66 \times 0.4^2 = 10.56$
51	61	-0.6	$61 \times 0.6^2 = 21.96$
50	46	-1.6	$46 \times 1.6^2 = 117.76$
49	18	-2.6	$18 \times 2.6^2 = 121.68$
48	13	-3.6	$13 \times 3.6^2 = 168.48$
47	4	-4.6	$4 \times 4.6^2 = 84.64$
46	1	-5.6	$1 \times 5.6^2 = 31.36$
45	1	-6.6	$1 \times 6.6^2 = 43.56$
44	2	-7.6	$2 \times 7.6^2 = 115.52$
43	1	-8.6	$1 \times 8.6^2 = 73.96$
	331		$\Sigma(\times)^2 = 1424.16$
Range C-43 to C-59		Standard deviation $\sigma =$	
Median value C-52		$\sqrt{\frac{\Sigma \times^2}{n-1}} =$	
Arithmetical mean C-51.6		$\sqrt{\frac{1424.16}{330}} = 2.08$	

steel plate made by three refining processes. This involved 13 variables for each thickness. Solution of 13 simultaneous equations relating yield strength (or tensile strength) to these variables as determined for 145 heats of steel would require about 20 hr. by the calculating machine at Harvard University, or 800 hr. if manually computed. This for each property for each thickness.

Faced by this formidable situation, 35 heats were selected, all made from semikilled steel and rolled into 1/2-in. plate. Yield strength at room temperature was plotted against variability in manganese content between 0.39 and 0.59%, carbon content between 0.10 and 0.26%, copper content between 0.20 and 0.30% and so on. A review of these charts showed that such incidental variation did not lower the property; any change was in the direction of a slight improvement. Similarly, charts plotting other properties against composition showed no detriment in strength or ductility at room temperature or at 400, 600, 800 and 1000°F.

In summary, it is hoped that variability has been described and identified in a few problems of wire production, corrosion test development, and hardenability evaluation. Some case histories have been detailed to reveal some of the modern statistical methods that are useful in the control of variability in steel technology. ☞

Large Power Reactor Authorized*

EARLY THIS YEAR the U.S. Atomic Energy Commission submitted to the National Security Council a statement of policy on the development of nuclear power.[†] The goal is a most difficult one, yet is essential to American leadership in the world. It is therefore proper to state some of the background.

Our atomic weapons program depends upon substantial quantities of uranium from friendly foreign nations which, I think, are motivated mainly by two beliefs: They believe in the military protection afforded by our atomic weapon potential. But they are also banking on the United States to help them build their nuclear power plants of the future. Unless we embark on a nuclear power program immediately, we may be deprived of foreign uranium ores with the result that our weapons potential will be smaller than need be the case. And so the two races—the atomic arms race and the nuclear industrial power race—are strangely related, and it should be quite clear that the stakes are very high.

Until recently, defense demands have limited large-scale nuclear power efforts primarily to military propulsion projects, such as submarine reactors. But the world situation, as well as the evolving progress of reactor technology, now calls for a great change of pace. With this in mind the Commission has embarked on a program to construct a power reactor to produce a minimum of 60,000 kw. of electrical energy. We hope to have it in operation in three to four years.

Because of Westinghouse Electric Corp.'s previous experience with the reactor system chosen,[‡] this company has been named principal contractor. Immediate responsibility for the job has been assigned to Rear Admiral H. G. Rickover, the Navy's reactor expert. The commission will welcome offers from industry to invest risk capital in the building of the steam and turbine portions, as well the operation of the entire plant.

The new nuclear power unit cannot compete in costs with conventional steam power plants. Nevertheless, we decided to construct a unit designed according to the technology known now or within reasonable reach of the engineer's grasp. We have much to learn that can only be learned by building and by operating, and we will really never know the answer to costs until we build and operate several large-scale reactors.

The new installation will not be a "dual-purpose" reactor, to produce *both* power and plutonium.

*Verbatim excerpts from remarks by Commissioner Thomas E. Murray, U.S. Atomic Energy Commission, before Electric Companies' Public Information Program, Chicago, Oct. 22, 1953.

†See *Metal Progress*, September 1953, p. 73.

‡Editor's GUESS—The submarine power plant (ship thermal reactor) successfully operated as a land-based prototype at Arco, Idaho. No detailed information about its construction has been released for publication.

[Former proposals] expected that the premium price for the plutonium would bear any excess cost of the power. But today we are organized to take care of present weapons' demand for plutonium from reactors either now in operation or nearing completion.

This first full-scale reactor will not, by any means, be the sole effort of the Commission in the nuclear power field. We will continue our general programs of research and development, and promote the construction of experimental reactors which appear to contribute substantially to the design of economic units.

And now let us consider a controversial subject—the political aspect of industrial participation:

The Commission's proposed policy, calling for both Government and private efforts in the nuclear power field, is an interim policy. As privately financed efforts gain momentum, the work should gradually be transferred from the Federal Government so that eventually industry will be carrying the greater part of the burden of this industrial development. Initially the Federal Government must sponsor and finance full-scale power reactor development, but this will fall far short of what is needed unless there are enlisted the cost-cutting drives, the informations, skill and competition of many segments of America's business and industry. The time has come to end the monopoly of power reactor information now shared between the Government and a few industrial concerns [which have been "cleared" for studies about power reactors].

I don't think it is generally understood that the basic problem to the question of industrial participation is the need for secrecy. Were it not for a proper concern that the U.S.S.R. would capitalize for war on our reactor ideas and technology, all reactor data could be immediately published—for all in the free world to work on. Secrecy is a necessary nuisance. It does slow down the work of the Commission. It costs immense sums. But let's not compound its restrictiveness by making it the basis of what would really be a political preference for public ownership. And so another point of the Commission's power policy states: "Progress toward economic nuclear power can be further advanced through participation in development programs by qualified and interested groups outside the Commission."

In conclusion, I see the United States nuclear power policy is calling now, in the year 1953, for early development of practical power reactors. This means attacking the problem on a broad front, extending from our weapons material producing reactors at one extreme, through military propulsion reactors, through government financed full-scale power producing units, all the way to privately financed research, development and ultimately private construction of full-scale units.

Corrosion—How Best to Study It

The September issue of *Metal Progress* carried a "Critical Point" entitled "Corrosion—Do We Know Anything Much About It?" in which the view was expressed that a wholly disproportionate amount of work is being done along the Edisonian cut-and-try plan and that much more effort should be expended on what might be called the fundamentals of the problem. He cited two "centers" of research whereas he should have said two centers of fundamental research—for everyone knows that much work on specific problems is being done in many well-staffed and equipped university, governmental, association and industrial laboratories. Among the letters received since that publication the two printed below well state the case both for and against the Editor's view.

For More Fundamental Research

By JOHN CHIPMAN

*Professor in Charge, Department of Metallurgy
Massachusetts Institute of Technology*

THE CRITICAL POINT entitled "Corrosion—Do We Know Anything Much About It?" in the September 1953 *Metal Progress* (p. 83) sets forth a very important and fundamental question. Research workers in the corrosion field would be practically unanimous in concurring with the answer that progress depends upon learning a lot more about it than we know at the present time.

And how do we start in to learn something about it? It is true that it won't be easy. The fundamental answers that are needed are not likely to be stumbled upon by following the "crisscrossed and well-worn paths of conventional test methods"—in the Editor's words. The underlying problems are those of physical chemistry and of physical metallurgy, and it should be clearly understood that where metals are concerned there is no line of demarcation between these two disciplines.

Stimulated by your Critical Point, I asked Prof. H. H. Uhlig of our department of metallurgy what he considered the important underlying problems in physical chemistry and physical metallurgy on which our further progress in understanding corrosion will depend. The following is quoted from Dr. Uhlig's reply:

"I believe that improved progress in controlling corrosion depends on . . . (Continued on page 170)

A Defense of Ad Hoc Studies

By FRANK L. LAQUE

*In Charge, Corrosion Research Section
International Nickel Co., Inc.*

IN CRITICAL POINTS, September, 1953, the Editor raised a question as to how much we know about corrosion, deplored the dependence on *ad hoc* or empirical tests in selecting materials to solve particular problems, and made a plea for the creation of a sort of intellectual hot house from which lightning-like strokes of genius might flash to illuminate the surrounding darkness.

Since I spend most of my time dealing with the practical aspects of corrosion by trying to apply available data to particular problems, I am in a good position to recognize not only the deficiencies of the *ad hoc* approach and the need for more fundamental knowledge but also the difficulties of applying fundamental information to the solution of practical problems.

I am very much in favor of stimulating fundamental research by such methods as providing an environment and atmosphere that will attract gifted scientists to throw light on this involved subject. But I do not believe that we should seek support for such an enterprise on the basis that what we are seeking is a number of "lightning flashes", in the Editor's words. Lightning-like illumination is characterized as much by its brevity as by its brilliance. I would prefer the kind of thinking and systematic effort that might be . . . (Continued on page 173)

Controlled Atmospheres— Their Generation and Utilization

THE NUMBER of possible combinations of controlled-atmosphere generators and furnaces available to the heat treating industry today is so large and varied that almost any desired metallurgical result can be produced. Choice of the proper combination is the joint responsibility of the supplier and the user, and should be made with due consideration to product quality, quantity, safety, economy and simplicity of operation. This implies closer cooperation between furnace manufacturer and heat treater than is normally necessary for other types of equipment.

The user of controlled atmospheres has a responsibility beyond the choice of equipment. The only purpose of a controlled atmosphere is the regulation of chemical reactions which will have an effect on the work he is treating. If he is to insure continued successful and economical operation during the lifetime of the equipment, he must have a good understanding of the process and exercise care in maintenance and control. It cannot be emphasized too strongly that vigilance pays dividends in the operation of controlled-atmosphere equipment.

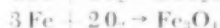
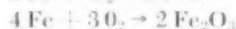
Controlled atmospheres in their more elementary forms have been widely used for more than 20 years. Relatively complicated and highly specialized types of atmospheres are in use today, and generators which will produce them in the easiest and most economical manner have been designed. Although commercial heat treating companies as well as many production plants have no extensive chemical or metallurgical facilities, they are, nevertheless, called upon to use controlled atmospheres in many processes. It is under such conditions that correct equipment, protective maintenance and working knowledge of the gas-metal reactions involved are essential.

Practically speaking, gas-metal reactions encountered in present day heat treating processes can be classified as (a) oxidizing or (b) reducing, and (c) carburizing or (d) decarburizing. (For a tabulation of these reactions, see *Metal Progress Data Sheet No. 63*.) An oxidizing re-

action will scale or discolor metal surfaces, whereas a reducing atmosphere will preserve clean metal and, in fact, can reduce oxides or scale to pure metal again. Carburizing or decarburizing reactions will affect those metals that either dissolve or give up carbon in the presence of a suitable gaseous atmosphere.

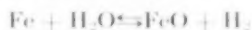
OXIDIZING-REDUCING REACTIONS

If, in the process of heating iron or steel — or any common metal — oxidation or scaling should be desirable, free oxygen or air would be an excellent atmosphere. If the metal were iron, one or more of the following oxidizing reactions would continue as long as any trace of free oxygen was present in the atmosphere:



These reactions may be termed irreversible; in fact, they are uncontrollable since no product except oxide is formed.

There are other oxidizing gas-metal reactions which, while they can produce all or most of the products formed by oxygen, are more useful because they can be controlled as to rate and extent. Thus, in the reactions



water vapor and carbon dioxide are the oxidizing gases. Unlike the reactions involving free oxygen, the products of oxidation now include hydrogen (H_2) or carbon monoxide (CO), both of which are reducing gases. It becomes evident that ultimately the quantity of reducing gas can become great enough to slow down and finally stop the oxidizing reaction of the water vapor or carbon dioxide. Furthermore, these reactions can be controlled so as to be

By O. E. CULLEN, Chief Metallurgist
Surface Combustion Corp., Toledo, Ohio

Equilibrium Ratios for Gas Atmospheres

oxidizing, reducing, or neutral, depending upon the amounts of the oxidizing or reducing gases present. Such reactions are called reversible and represent the most elementary types of controlled atmosphere. Once the values for reversible reactions involving a particular metal are known, it becomes possible to produce a suitable controlled atmosphere for that metal.

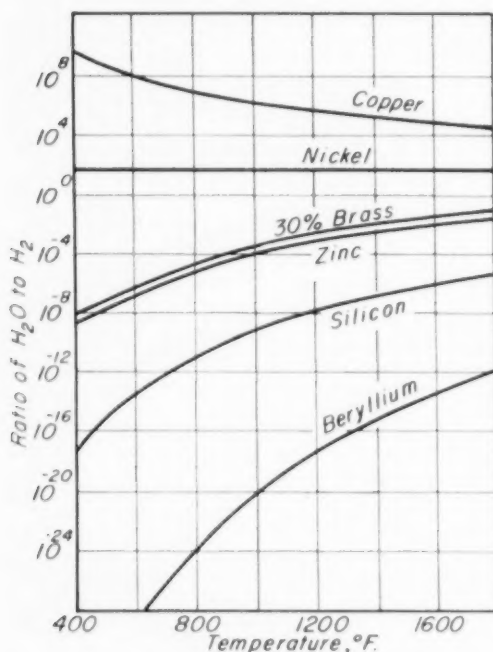
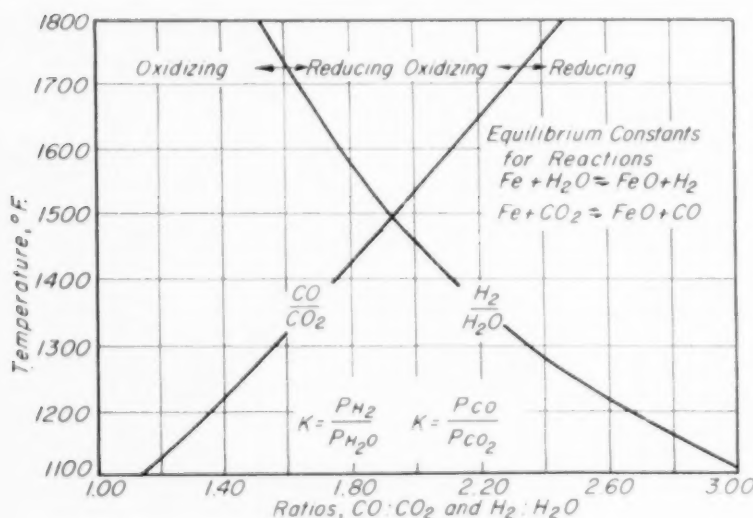


Fig. 1 — Ratios of Water Vapor to Hydrogen for Various Metal-Metal Oxide Equilibria as Functions of Temperature



This introduces a well-known constant depending upon the temperature of the reaction, thus:

$$K(\text{Temperature}) = \frac{(\text{CO}_2) \cdot (\text{H}_2)}{(\text{CO}) \cdot (\text{H}_2\text{O})}$$

CONTROLLED-ATMOSPHERE GENERATORS

The earliest controlled-atmosphere generators were based on the principles of partial combustion of hydrocarbon gas with

In Fig. 1, equilibrium ratios of water vapor to hydrogen are shown over a range of temperatures for four common and two uncommon metals. Above each equilibrium curve the mixture of H_2O and H_2 becomes oxidizing, and below each curve it becomes reducing. The curve for copper illustrates why this metal may be clean annealed in an atmosphere of substantially pure steam. The curves also indicate why nickel (and iron) are relatively easy to anneal without oxidation, whereas brass, zinc (and, similarly, chromium and stainless steels) are difficult to keep bright or clean without dry, high-hydrogen atmospheres and special air-tight furnace equipment.

It should be noted that, as a rule, lower ratios of water vapor to hydrogen are required at the lower temperatures. It is for this reason that an atmosphere with controlled moisture content usually is introduced directly into the low-temperature zones and cooling chambers of continuous furnaces during annealing processes.

When treating iron or steel, other active gases may be used to advantage. In Fig. 2 the carbon monoxide-carbon dioxide equilibrium ratios are included along with the hydrogen-water vapor ratios for a considerable range of temperatures. These curves show that while a reducing atmosphere will tolerate increasing amounts of water vapor (compared to hydrogen content) with increasing temperature, the direct opposite is true of the CO_2 in the $\text{CO}:\text{CO}_2$ ratios. The opposing actions of these ratios may be combined and controlled according to the well-known water-gas reaction

Fig. 2 — $\text{CO}:\text{CO}_2$ and $\text{H}_2:\text{H}_2\text{O}$ Equilibrium Constants for Oxidizing-Reducing Reaction With Iron or Steel. Note that the $\text{H}_2:\text{H}_2\text{O}$ ratio (horizontal) is vastly magnified over Fig. 1

air to form a gaseous mixture containing carbon monoxide, carbon dioxide, hydrogen and water vapor in controlled quantities to obtain the desired reaction. This exothermic type of controlled-atmosphere generator is still one of the most widely used in the bright or clean annealing of copper, copper-rich alloys and low-carbon steels. In its simplest form the exothermic atmosphere generator shown diagrammatically in Fig. 3 consists essentially of a mixer for hydrocarbon gas and air, a mixture pump, a combustion chamber and a water cooler of direct or indirect type as may be required.

This exothermic or "DX type" of controlled atmosphere was the forerunner of a number of different types of atmospheres, each designed for particular heat treating applications and all derived from readily available supplies of hydrocarbon fuels such as natural gas or propane. Table I gives approximate analyses of these atmospheres. (See also *Metal Progress Data Sheet No. 64.*) With the exception of the DX and RX gases, these atmospheres are used mainly in manufacturing where large-volume generators are required. The NX, HNX and HX types of atmospheres are produced from hydrocarbon fuels reacted at high temperatures with air, steam or both, and then subjected to exacting supplementary treatments involving chemical absorption, catalytic conversion, and drying to remove undesirable constituents. Generators have been perfected to produce these controlled atmospheres in the limited quantities required, and it is expected that they will become increasingly useful in the general heat treating field in the future.

The endothermic (RX) type of atmosphere contains substantially none of the oxidizing gases—carbon dioxide and water vapor—but does contain appreciable amounts of the reducing gases, carbon monoxide and hydrogen. The gas-air mixture required to produce such an atmosphere is too rich in hydrocarbon to burn; hence a source of external heat and presence of a catalyst are required to bring about the desired reactions. As shown in Fig. 4, the endothermic generator consists

Exothermic and Endothermic Generators

of a gas-air mixer, a mixture pump and one or more externally heated retorts in which the gas-air reaction takes place in the presence of a nickel catalyst. All gaseous reactions are completed in the retorts and the reacted gas is generally cooled for transmission to point of use. Sometimes the generator is included in the heat treating furnace and no intermediate cooling zone is required.

Endothermic atmospheres are widely and almost exclusively used for carbon control in the heat treatment of steel. It cannot be emphasized too strongly that in such installations it is vitally important to understand not only the operation and correct adjustment of the atmosphere generator but also the reactions which go on in the heat treating furnace and the influence of both generator and furnace on these reactions.

CARBURIZING-DECARBURIZING REACTIONS

While it is recognized that many metals react chemically with carbon, the essential reactions involving carbon and iron or steel (with no reference to presence of alloying elements) are as follows:

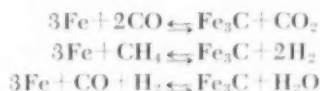


Table I—Compositions of Hydrocarbon Gas Atmospheres*

TYPE OF GAS	GAS CONSTITUENTS, % BY VOLUME					
	CO ₂	CO	H ₂	CH ₄	H ₂ O	N ₂
RX	0.0	20.7	38.7	0.8	0.0	39.8
DX (Lean)†	10.5	1.5	1.2	0.0	0.8	86.0
DX (Rich)†	5.0	10.5	12.5	0.5	0.8	70.7
NX	0.05	1.5	1.2	0.0	0.0	97.25
HNX	0.05	0.05	3.0-10.0	0.0	0.0	Balance
HX	0.05-2.0	0.05-1.0	50-99.8	0-0.4	0-3.5	Balance

*Based on use of natural gas for atmosphere production.
†40° F. dew point.

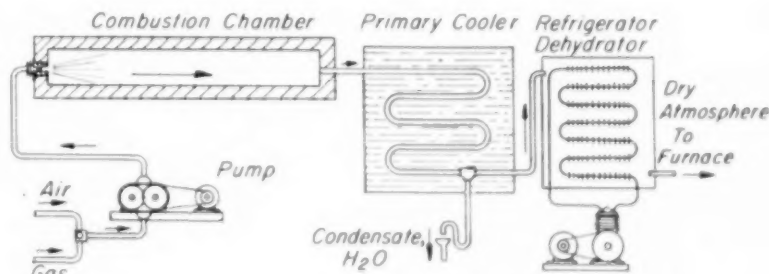
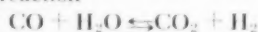


Fig. 3—Exothermic Gas Generator, DX Type

Carburizing Reactions

It is evident that carbon monoxide (CO) and methane (CH₄) are carburizing gases, and that carbon dioxide, water vapor and hydrogen are decarburizing. These carburizing reactions are reversible and the governing equilibrium ratios of CO:CO₂, CH₄:H₂ as well as CO:H₂:H₂O have been described in *Transactions*, Vol. 38, 1947, p. 659. The endothermic type of atmosphere with approximately 20% CO, 40% H₂ and 40% N₂ has become almost universally recognized as a ready source for obtaining the desired carbon content in any heat treating process. The equilibrium values for CO:CO₂ ratios necessary for carbon concentration over the entire carburizing range have been worked out ("Dew Point Vs. % CO₂ as Furnace Atmosphere Control Check," by W. J. Groves, *Industrial Heating*, June 1949). Figure 5 shows an example of such values at 1700° F.; it is evident that the CO₂ content for controlling carbon with the endothermic type of atmosphere is very small and the accuracy of reading these CO₂ values is beyond the usual limits of error. Groves has also shown that the water-gas reaction



represents a definite relationship at any given temperature between the H₂:H₂O ratio and CO:CO₂ ratio in the furnace atmosphere (Fig. 6). Therefore, either CO₂ or H₂O (as represented by dew point) can be used for evaluating and controlling carbon balance in furnace atmospheres.

Figure 7 has been drawn to show the percentages of CO₂ and the dew points in balance with various carbon contents in steel at 1700° F.

Fig. 4 - Endothermic Gas Generator, RX Type

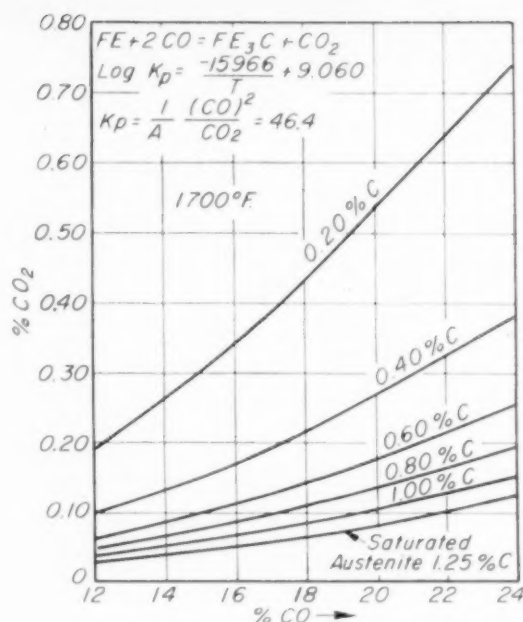
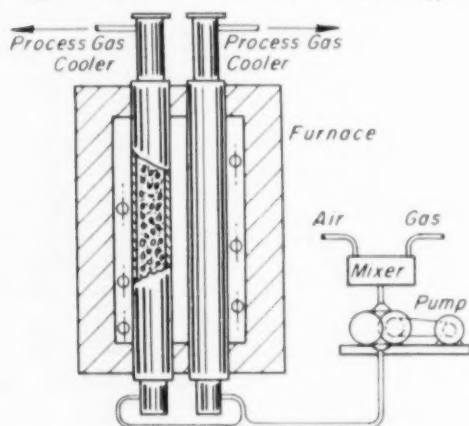
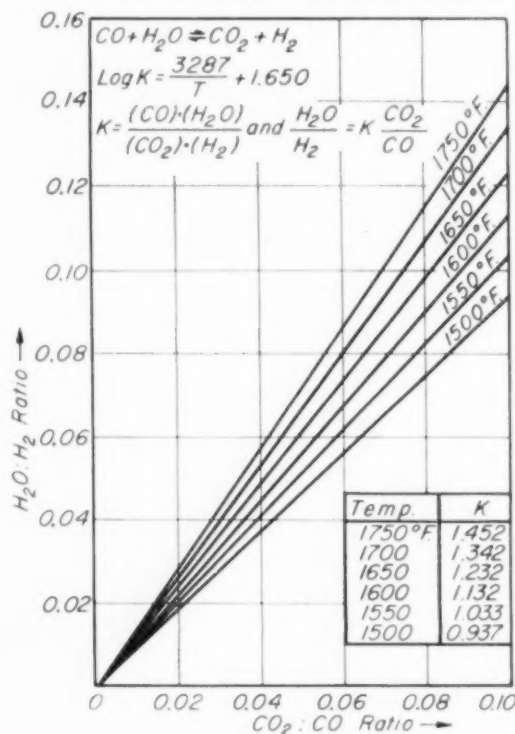


Fig. 5 - CO₂ and CO Percentages in Equilibrium With Various Carbon Concentrations at 1700° F. (Groves)

Fig. 6 - Relationship Between H₂O:H₂ and CO₂:CO Ratios at Different Temperatures in Accordance With the Reaction CO + H₂O \rightleftharpoons CO₂ + H₂. (Groves)



when heat treating in an endothermic atmosphere of 20% CO, 40% H₂ and 40% N₂. For equilibrium with a carbon content of 0.50%, an Orsat reading of 0.20% CO₂ and a dew point thermometer reading of 29° F. are required. For equilibrium with 0.60% carbon, the CO₂ reading must be 0.16% and the dew point reading 24° F. The difference in CO₂ readings for 0.10% carbon is 0.04% on the Orsat, whereas the difference in dew point thermometer readings is 5° F.

Figure 8 shows the limits of accuracy in controlling carbon by CO₂ and dew point readings, assuming that Orsat readings can be accurate within ± 0.05 cc. and the thermometer readings within $\pm 1^\circ$ F. The chart shows, for example, that 0.60% carbon in steel can be controlled by Orsat readings of CO₂ only within limits of $\pm 0.135\%$ carbon or within a range of approximately 0.47 to 0.73%. By dew point determination the limits of control are $\pm 0.023\%$ or within a range of approximately 0.57 to 0.63%.

The usefulness of dew point control with endothermic-type atmospheres has been well proven in theory and practice. In Fig. 9 the curves represented by solid lines are drawn from theoretical data while each point on the chart represents an individual result obtained from actual furnace operation.

PRACTICAL CARBON CONTROL

It has been demonstrated above that an endothermic type of atmosphere, with proper adjustment of dew point or water vapor content, can be used to control the surface carbon of steel during heat treatment. In other words, a method is provided whereby steel of any particular carbon content can be hardened without substantial gain or loss of carbon at the surface. Also, steel which has been previously decarburized can be treated so as to restore the lost carbon; this may often be done during heating for hardening. A low-carbon steel can be carburized to any desired case depth with the assurance that a definite surface carbon concentration can be obtained. Examples of surface carbon control for carburizing over a relatively wide range of carbon potentials and case depths are shown in Fig. 10 on p. 106.

The foregoing discussion has been limited to the use of carbon monoxide as the carburizing gas merely to demonstrate

Dew-Point Control

the equilibrium conditions for maintaining desired carbon balance between a furnace atmosphere and steel surfaces. Actually, if there is any appreciable demand for transfer of carbon from the furnace atmosphere to the steel (as is true in most processes, including carburizing, carbon restoration and homogeneous carburizing), it becomes necessary to provide a sufficient extra supply. Carbon monoxide itself can yield only a little carbon to the steel, and only at the expense of upsetting equilibrium conditions. It is general practice, therefore, to supply the necessary carbon in the

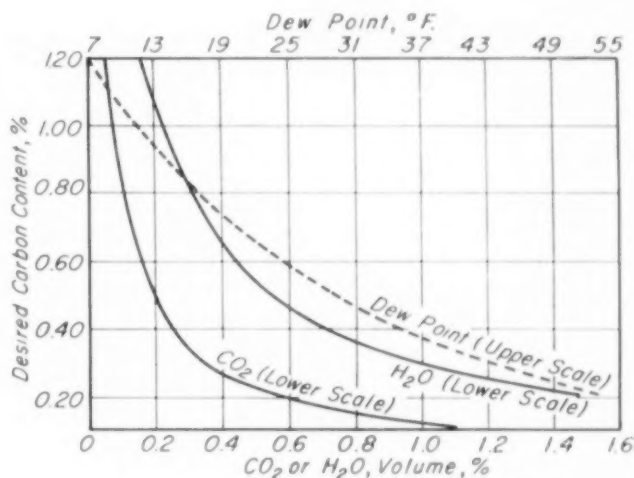


Fig. 7—Carbon Control in Heat Treatment of Steel by CO₂ or H₂O Determination Using an Atmosphere of 20% CO, 40% H₂ and 40% N₂ at 1700° F.

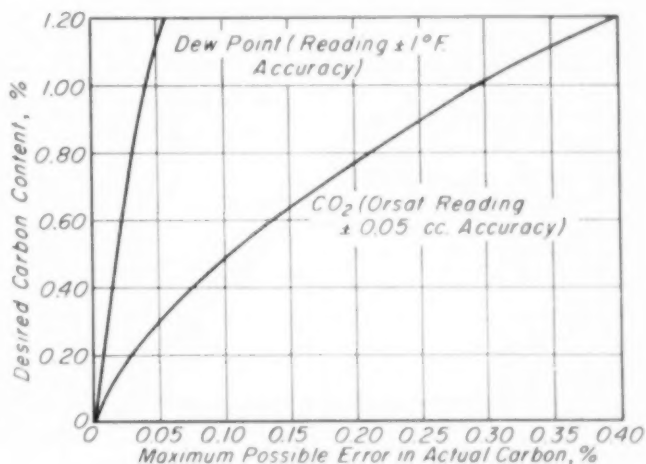


Fig. 8—Limits of Accuracy in Controlling Carbon by Dew Point Vs. CO₂ Determination. Atmosphere is 20% CO, 40% H₂ and 40% N₂ at 1700° F.

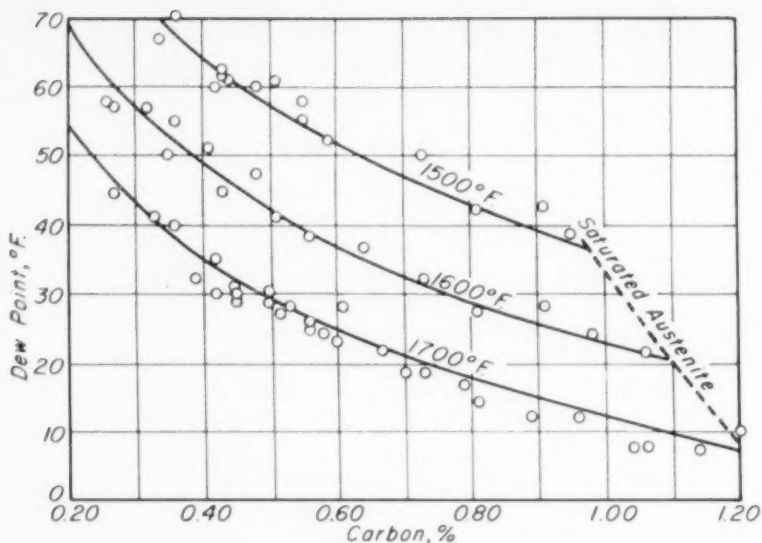


Fig. 9 - Dew Point as a Function of Austenite Carbon Content and Temperature for 20% CO, 40% H₂

form of a hydrocarbon gas added in carefully controlled quantities. For instance, a small amount of propane or natural gas (which usually contains a large percentage of methane) will provide the necessary enrichment. The available carbon in this methane or propane at carburizing temperatures is many times that of the CO in the generator gas. By controlling the amount of hydrocarbon gas on the basis of carbon demand by the steel, it is still possible to utilize the dew point method for controlling carbon balance between work and furnace atmosphere. This is true below the composition range for saturated austenite. Above this saturation range, time at temperature becomes the controlling factor—that is, surface carbon content of steel will increase with time.

Before the introduction of the endothermic type of atmosphere for gas carburizing, prepared gases containing relatively large amounts of carbon dioxide and water vapor were used, and it was necessary to add large amounts of hydrocarbon gases to overcome the bad effects of these constituents. The excess of hydrocarbon precluded the possibility of accurate surface carbon con-

trol and also led to soot deposition. This soot presented a cleaning problem and—far more important—the heat resisting alloy used in furnace parts deteriorated rapidly.

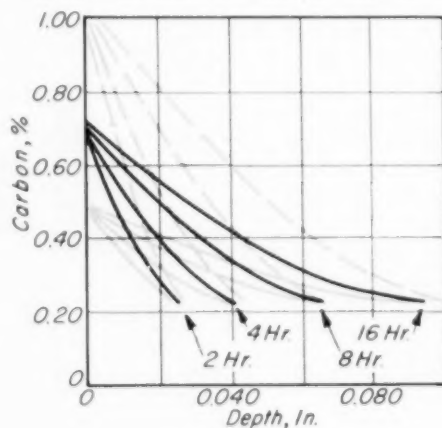
CARBO-NITRIDING

Further investigation of endothermic atmospheres brought out the possibilities of carbon control over all ranges. In gas cyaniding processes such as carbo-nitriding or dry cyaniding, endothermic gases become the element for carbon control as well as the diluent for ammonia gas which introduces the nitride constituent. Proper control of both dew point and ammonia content is necessary for such operations.

Processes involving carbon restoration at the surface and homogenous carburizing have been used in large production furnaces for some time, and hold promise for commercial heat treating plants and small industries as well. In these more specialized processes the prospective user must familiarize himself with the reactions involved and the best means for controlling them.

Uniformity of process control is obtained by a regular check on controlled atmospheres and furnace operating conditions. The frequency of such checks will depend upon the process. Competent foremen should be made responsible for continuous records of gas analysis, dew point and furnace condition. The equipment for making these records, such as Orsats, temperature indicators or recorders, portable dew-point instruments and automatic dew-point recorders, is readily available and comparatively easy to operate. If such testing equipment is used regularly, and the results interpreted properly, prompt adjustment can be made to the atmosphere generator, the heat treating furnace or the method of operation.

Fig. 10 - Carburizing Curves for Various Times and Carburizing Potentials. E.A.E. 1022 steel; RX Gas at 1685° F. Solid curves in color are for carbon potential of 0.50% C, black curves for 0.75% C, and dashed lines in color for 1.10% C



ELECTROMET *Data Sheet*

A Digest of the Production, Properties, and Uses of Steels and Other Metals

Published by Electro Metallurgical Company, a Division of Union Carbide and Carbon Corporation, 30 East 42nd Street, New York 17, N. Y. • In Canada: Electro Metallurgical Company of Canada, Limited, Welland, Ontario

MANGANESE . . .

Deoxidizer and Toughener for Steel

Manganese is one of the most important alloys used in making steel. It is practically indispensable as a deoxidizer and cleanser for improving the hot-working properties of steels. When used as an alloying element, it makes steel stronger and tougher and it is therefore an important constituent of many structural and engineering steels.

Deoxidizes and Cleans Steel

The effectiveness of manganese in deoxidizing steel was first recognized in 1856, when it was used in the Bessemer process of steelmaking to counteract the bad effects of sulphur; in fact, manganese made this process a commercial success. Today, manganese is used as a deoxidizer and cleanser in the production of nearly all grades of open-hearth and electric-furnace steel, as well as high-grade cast iron.

Research work carried out recently in ELECTROMET's laboratories at Niagara Falls, New York, has provided new and important information on the value of manganese as a deoxidizer. This work shows that manganese is a more effective deoxidizer than has been previously realized; and that a combination alloy of silicon and manganese is a much stronger deoxidizer than either silicon or manganese by itself. Complete information is given in a report entitled "Solubility of Oxygen in Liquid Iron Containing Silicon and Manganese." If you would like a copy of this report, free of charge, write to the address above.

Improves Hot-Working Properties

By combining readily with sulphur, manganese performs another valuable job, it removes the principal cause of hot-shortness or brittleness—thereby giving steel better rolling and forging properties. In this reaction, the manganese combines with the sulphur to form manganese sulphide, as follows:



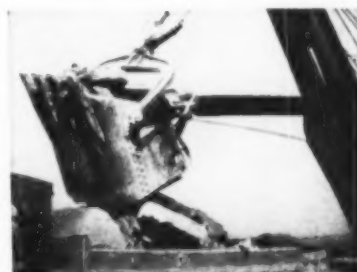
The manganese sulphide remaining in the steel is a less harmful type of inclusion than the iron sulphide would be, and the hot-working properties of the steel are improved.

The weakening and embrittling tendencies of sulphur in cast iron can also be counteracted by the addition of manganese to the cupola charge.

Increases Strength, Toughness, and Wear-Resistance

When used as an alloying element in steel, manganese produces a steel with greater strength and toughness, and there is no serious loss of ductility. Additions of about 13 per cent manganese produce the well-known Hadfield manganese steel. High-manganese steels have exceptional resistance to wear; and consequently they have many applications in engineering jobs. Instead of wearing away quickly under conditions combining severe pressure, shock, and abrasion, these steels actually become harder through use. Thus, they last longer.

Because of the tendency of high-manganese steels to work-harden, they serve industry in important and varied applications. Manganese steel castings, for example, are used for railroad frogs and crossings, rock crusher parts, steam-shovel dipper



Dipper bucket teeth, cast of Hadfield manganese steel, actually increase in hardness under abrasive wear from gravel and rock in construction work — thus last many times longer than those of ordinary steel.

teeth, and dredge-bucket lips. The chief applications of manganese steel are in rails used for special service, and light forgings subjected to heavy wear.

ELECTROMET Alloys

Manganese is produced by ELECTROMET in forms suitable for practically every use of the iron, steel, and non-ferrous metal industry. Some of the ELECTROMET products are listed below. For a complete description of these alloys, write for a copy of the booklet, "ELECTROMET Products and Service."

The terms "EM" and "Electromet" are registered trade-marks of Union Carbide and Carbon Corporation.

Alloys of Manganese and Their Uses

Standard Ferromanganese	The product most commonly used for adding manganese to steel for the purpose of alloying or deoxidizing and cleansing.
Low-Carbon Ferromanganese	For adding manganese to steels having a low carbon content, such as stainless steels of the 18 per cent chromium, 8 per cent nickel type.
Medium-Carbon Ferromanganese	Commonly used for making manganese steel containing 1.50 to 2.00 per cent manganese, and in the production of Hadfield manganese steel.
Low-Iron Ferromanganese	For applications in the nickel, aluminum, and copper industries where a low-iron alloy is required.
Silicomanganese	Used by the steel industry as a furnace block; as a deoxidizer; and also for manganese additions, particularly in the production of engineering steels containing 0.10 to 0.50 per cent carbon.
"EM" Silicomanganese Briquets	For adding manganese (with silicon) to cast iron in the cupola.
"EM" Ferromanganese Briquets	For adding manganese (without silicon) to cast iron in the cupola.

Correspondence

Radiographic Studies of Segregates

PARIS, FRANCE

Dendritic segregation plays an important role in the directional properties of wrought steel by virtue of the fibrous structure in such products. The intensity of dendritic segregation (that is, the maximum variation of concentration) depends on the freezing conditions and the thermal history of the solid steel, and the elements under consideration. It appears as a ghost structure, the macrostructure being dendritic in non-wrought steels and fibrous in wrought steels. This macrostructure can be revealed by chemical reagents, but only to the extent of providing an over-all picture of the heterogeneity of concentration without revealing the effects of the individual elements. This has contributed to different opinions that attribute the etched structure to phosphorus, oxygen, and others. It is probable, as W. Grosse points out, that dissolved oxygen intensifies the segregation of phosphorus.

Fig. 3—Steel Ingot Rejected for Ghost Lines. Macrograph obtained with Humphrey's reagent (left); radio-autograph (right)

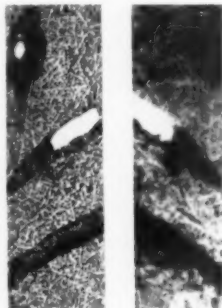


Fig. 1—Dendritic Segregation Shown by Radio-Autograph of a Steel With 0.76% C Containing 1.20% P. 10×

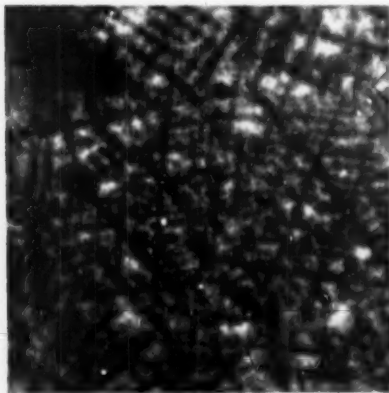
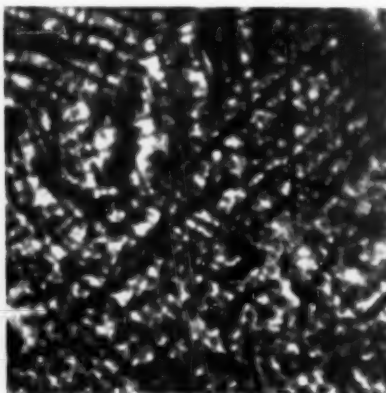


Fig. 2—Structure of a Steel Containing 0.52% C and 0.34% P Irradiated Directly at the Chatillon Pile. 5×



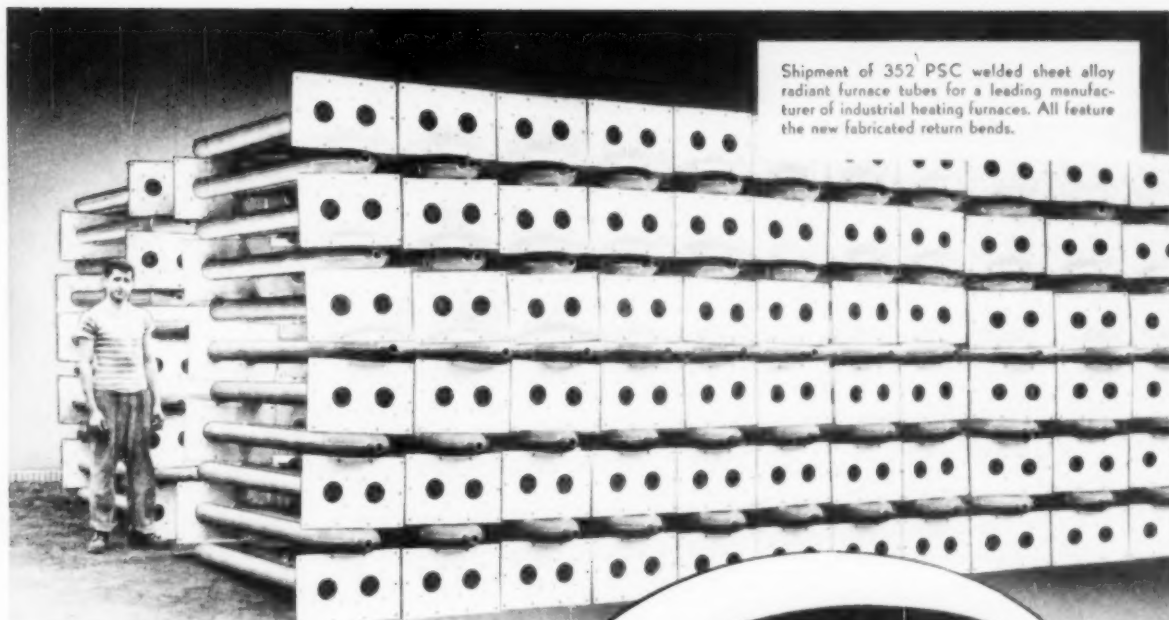
Z. Weinstein and I have tried extending Bauman's method of sulphur printing by impregnating a gelatinized paper with an attacking reagent (for example, an acid) and a reagent that becomes colored when a specific metal is dissolved in its presence (such as dimethylglyoxime for nickel) as described in *Metal Progress*, March 1933, p. 52. We had no success with the method.

However, the idea was suggested that the use of radioactive elements offers a general solution to the problem, inasmuch as a direct photographic image of the distribution of the metal in question can be obtained. (See also "Radio-Autographic Determination of Lead in Stainless", *Metal Progress* for July 1951, p. 65.) Two possibilities arise with this method: The radioactive element could be introduced to the heat as ferro-alloy, or a plate exposed to neutron bombardment in an atomic pile could be used as the sample.

In the first method a single metal can be studied, but the method can be used only on small heats especially prepared for this purpose. The second is a more general method because it can be used on industrial ingots of carbon steel. André Kohn used this method at the laboratories of the Research Institute for Ferrous Metallurgy (IRSID) to reveal phosphorus and, to a certain extent, arsenic segregation, these being the only elements that give a photographic impression when the steel is exposed to a 48-hr. bombardment.

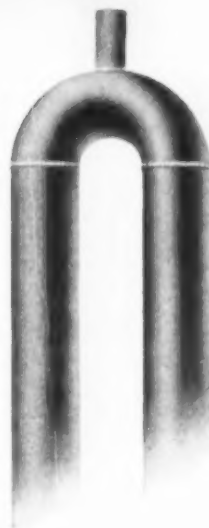
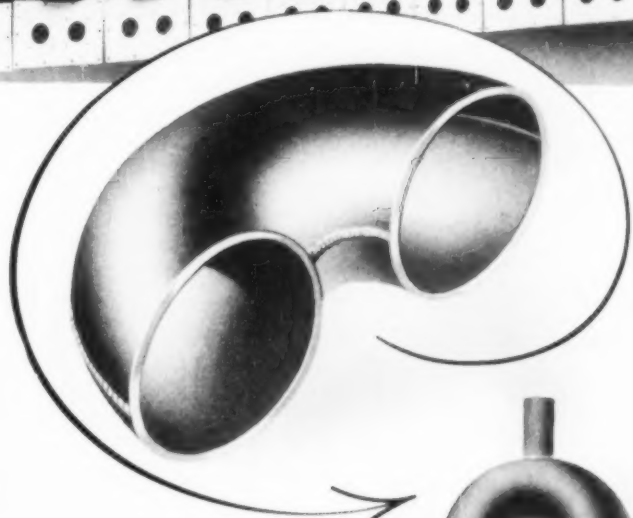
Traces of chromium in the steel reduce the definition in radio-autographs because chromium radiation causes considerable background fog. Traces of nickel or molybdenum are less troublesome.

Figure 1 is a print at 10× from a radio-autograph of steel of 0.76% C and 1.20% P, the sample coming from a small heat made with additions of ferrophosphorus containing 15% radioactive phosphorus obtained by irradiation at the Chatillon pile. Figure 2 is a print at
(Cont. on p. 110)



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Correspondence

5 dia. of a 0.52% C, 0.34% P steel irradiated directly at Chatillon. These clearly show the dendritic segregation of phosphorus. The first experiment with radioactive sulphur gave results similar to those in a normal sulphur print.

Figure 3 is a comparison of a macrograph obtained with Humphrey's reagent (left) and a radio-autograph (right) of an ingot of steel (0.56% C, 0.62% Mn, 0.44% Si, 0.39% Ni) which had been rejected for ghost lines. The autograph was made under conditions that rendered the arsenic more active than phosphorus. The veins are obviously rich in arsenic, a fact which is confirmed by the chemical analysis which disclosed 0.073% arsenic and 0.033% phosphorus in the lines as compared with 0.050% arsenic and 0.020% phosphorus near the lines.

This technique need not be confined to steels but offers a valuable new method of analyzing dendritic segregation in other metals also.

ALBERT M. PORTEVIN.

The Lighter Side of a Light Metal

PORTSMOUTH, VA.

Many strange designs have been observed in the microstructures of metals and alloys, but seldom do these designs take on any recognizable form. Recently, while making a routine microscopic examination of an aluminum alloy cast in our foundry, I chanced upon the accompanying design. Perhaps your readers will appreciate this "lighter side" of the metallography of aluminum alloys. It shows, at 500 \times , what I have called the "fourth phase" of this alloy. Actually, I believe it to be the Mg-Si phase separating out in the surprising numerical pattern below.

L. R. ABBOTT, JR.

Metallurgist

Norfolk Naval Shipyard



METAL PROGRESS; PAGE 110

Detonation of Ti Alloy in Red Fuming Nitric Acid

DOWNEY, CALIF.

Our material research engineers suggest that you might be interested in a safety item concerning the handling of titanium-manganese alloys which have been corroded by red fuming nitric acid. The spongy residue of the alloys, which is formed after prolonged exposure to red fuming nitric acid, can be exploded by scratching the surface or by heating the material.

Extreme caution is urged in the handling of all titanium alloys which have been exposed to red fuming nitric acid, pending further investigation of safe handling methods.

JAMES F. SCHIER

North American Aviation, Inc.

Mechanical Properties of Carbo-Nitrided Cases

CAMBRIDGE, MASS.

The main objective of the article, "Structures and Properties of Some Carbo-Nitrided Cases" by K. B. Valentine in the June 1953 issue of *Metal Progress* appears to be an evaluation of the toughness of carbo-nitrided parts by bending and impact fatigue tests. Data of this kind have long been needed and Mr. Valentine has made a considerable contribution to the subject, but his experiments and interpretations call for comment.

A fundamental objection to this investigation concerns the conditions of carbo-nitriding, which are not representative of current practice. The treatments by which Mr. Valentine's specimens were made produce poor surfaces on the carbo-nitrided parts, which are certain to give poor results in bending and impact fatigue tests. Such surfaces are not formed in modern practice on parts that must have good fatigue and impact properties. The atmospheres and temperatures used in making Mr. Valentine's specimens would be satisfactory for parts that must only withstand simple wear.

Carbo-nitriding is practiced to a very limited extent in the range 1200 to 1400° F. Cycles similar to the author's treatments A and C are occasionally employed in industry. His treatment B comes closest to modern practice, but the ammonia concentration in the inlet gas should be given as 5% or less instead of 18%.

Correspondence

Also 1550° F. is a comparatively low temperature. The temperature range of carbo-nitriding for best mechanical properties extends as high as 1650° F. A decrease in ammonia and an increase in temperature would result in eliminating the outer layer present on the author's specimens and would improve their performance in bending and impact fatigue tests. The amount of retained austenite would also be reduced and this would raise the hardness values.

For given concentrations of nitrogen and carbon, carbo-nitrided cases are essentially the same as cyanided cases and should give similar results. The carbon and nitrogen concentrations can be controlled in carbo-nitriding by control of the temperature and the ammonia content of the furnace atmosphere.

Mr. Valentine's carbo-nitrided cases tend to have maximum hardness values not at the surface but at a depth of 0.004 to 0.006 in. The plain carbon steel carbo-nitrided by treatment B is actually harder at that depth than the maximum hardness of the cyanided cases.

The dark constituent at the surface of carbo-nitrided cases was mentioned by Bever, Floe and Zaruba in the May 1953 issue of *Industrial Heating*. It seems doubtful that this constituent is carbon precipitating out of solution because of the loss of nitrogen. Specifically, the statement by Rengstorff and his associates to which Mr. Valentine refers concerns the probable loss of nitrogen at rates of cooling slower than air cooling. At commonly used cooling rates, such as oil quenching, nitrogen loss would be negligible. The dark constituent is only found in the outer or compound layer. Since no such layer is formed in the most representative carbo-nitriding practice, the dark constituent is only of limited interest.

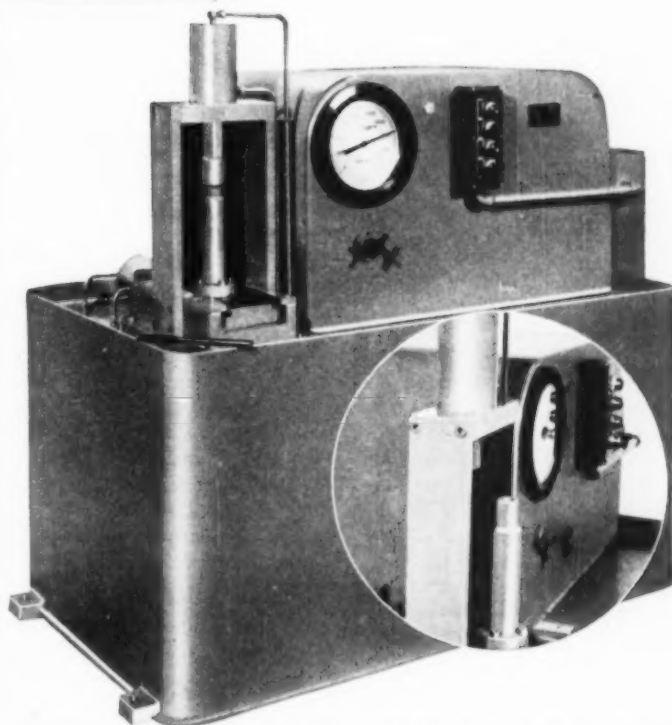
In conclusion, while Mr. Valentine's work is valuable in drawing attention to the important problem of the mechanical behavior of carbo-nitrided cases, it does not provide a sound basis for a comparison of carbo-nitrided and cyanided cases.

M. B. BEVER and C. F. FLOE
Department of Metallurgy
Massachusetts Institute of Technology

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Personal Mention



R. E. Christin

R. E. CHRISTIN ("Ernie" to his many friends) has resigned as chief metallurgist for the Columbus Bolt & Forging Co., Columbus, Ohio, a position he has held for the past 29 years. Mr. Christin will devote his entire time to metallurgical consultation on steel specifications and steel processing in the Columbus area. He will continue to operate his own company, the Electric Heat Treating Co., which has been servicing Columbus firms by scale-free heat treatment in molten salt baths for the past two years. Prior to joining Columbus Bolt & Forging Co. in 1924, Christin was assistant metallurgist at Chrysler Corp.'s Highland Park plant and also an assistant melter on the electric furnaces at the Highland Park plant of the Ford Motor Co. He is a graduate of the University of Detroit, class of 1920, with a bachelor of science degree in mechanical engineering, and is an Ohio State registered professional engineer. He is a charter member of the Columbus Chapter and has served that group as secretary for 17 years. Mr. Christin is also a member of the American Welding Society, American Society of Safety Engineers and the Foremen's Club of his home city.

R. E. Sheffer is now manager of the Chicago Works of the Aluminum Co. of America.

Thomas Rutherford has been elected a director of the Alloy Casting Institute of Long Island, N.Y.

John J. McGrann has been promoted from sales engineer to district manager of the steel and tube division, in charge of the Houston, Tex., office of Timken Roller Bearing Co.

Walter J. Prochak has been appointed assistant superintendent of the cold drawn bar department at the Brier Hill works of the Youngstown (Ohio) Sheet and Tube Co.

John E. DeMoss, formerly assistant professor of metallurgy at the University of Notre Dame, having served twelve years as a faculty member, has accepted the position of chief metallurgist at Keystone Carbon Co., St. Mary's, Pa., and will be concerned primarily with developments in the field of powder metallurgy.

Moses A. Levenstein has completed two years' active duty with the Navy as laboratory officer at the USN Metals Laboratory, Munhall, Pa., and is now employed at the aircraft gas turbine division of General Electric Co. at Evendale, Ohio, as a welding engineer.

Daniel J. Gentile has joined the Lindberg Steel Treating Co. as a sales engineer for the Los Angeles division, after having been associated with Federal-Mogul Corp. for 25 years.

Frans Josef H. Rolink, formerly chief metallurgist for Doorne's Truck and Trailers, Eindhoven, Holland, has joined Lips' Propellor Works, Drunen, Holland, as assistant to the manager. Mr. Rolink was representative for the Netherlands at the first World Metallurgical Congress in Detroit in 1951.

Peter Arnold, after graduating from Arizona State College, is employed in the engineering department of the Conveyor Co., Los Angeles.

John C. Bronson has joined the staff of the Los Alamos Scientific Laboratory of the University of California. Mr. Bronson was formerly employed by the Colorado Fuel and Iron Corp., Pueblo, Colo.

Clayton H. Carleton, who was formerly director of research for Federal Machine & Welder Co., Warren, Ohio, is now a member of the staff of the Warren G. Harding Senior High School in the same city.

Erwin O. Deimel, formerly research associate in the metallurgy department at Columbia University, is now senior research metallurgist with Utica Drop Forge and Tool Corp., Utica, N.Y.

Lee P. Johns has accepted a position as patent lawyer with Frease & Bishop, Canton, Ohio, after four years with the patent division of Argonne National Laboratory.

Ralph I. Swanson, formerly supervisor of research at the Gary Steel Works, division of U. S. Steel Corp., has been promoted to assistant to general superintendent of the Canton (Ohio) Roll & Machine Works of the corporation.

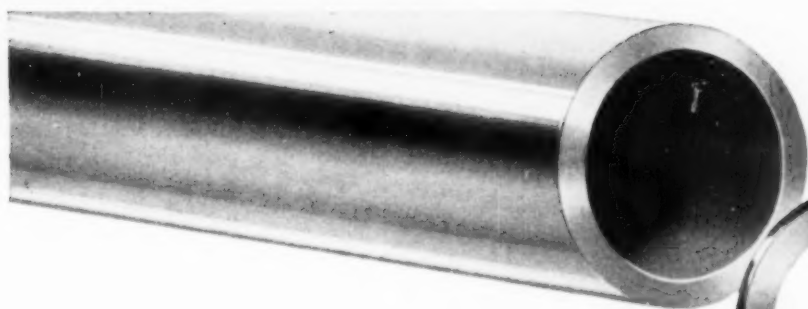
Charles Yaker has resigned from the scientific laboratory of the Ford Motor Co., where he held the position of supervisor of the foundry section, to join the Misco Precision Casting Co. as production manager of the Detroit plant.

L. G. Loseke, upon graduation from the Colorado School of Mines, was employed as a metallurgist by the Caterpillar Tractor Co., Peoria, Ill., and is now in the graduate training program of this company.

William A. Beck has accepted a position as assistant supervisor of the melting department of the Bay City (Mich.) Foundry of the Dow Chemical Co.

John J. Pierce has joined the staff of the National Bureau of Standards, Corona, Calif., as physical science administrator.

Dale Thomas Williams has been employed by Phillips Petroleum Co., Louisville, Ky., since graduating from the University of Kentucky.

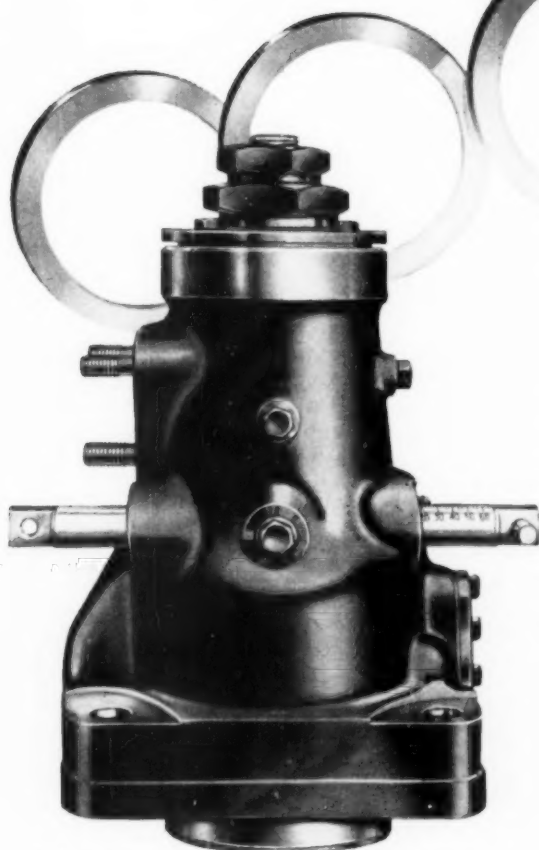


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Personals

Sidney M. Lenhoff ☼, formerly employed with the U. S. Naval Bureau of Ordnance, Washington, D.C., as metallurgist, is now deputy (assistant) chief of Materials Branch, Detroit Tank Arsenal.

George R. Sublett ☼, who graduated from Lehigh University in June, has accepted an assignment as metallurgical trainee at Reynolds Alloys Co., Sheffield, Ala.

C. M. Capka ☼ has been transferred from the St. Louis office of the Eclipse Fuel Engineering Co. to the Kansas City, Mo., office as manager.

Harold M. Cobb ☼ formerly unit head of the fabrication methods unit in the metallurgical engineering division of Wright Aeronautical Div., Curtiss-Wright Corp., Wood Ridge, N.J., is now metallurgist in charge of research and development, special products division of R. Wallace & Sons Mfg. Co., Wallingford, Conn.

Rollo W. Boring ☼, formerly sales manager of Rolled Alloys, Inc., Detroit, was recently elected vice-president in charge of sales. **Robert C. Ford** ☼, formerly associated with Carpenter Steel Co., Alloy Tube Division, has been appointed territorial manager of the same company and will be located in Pittsburgh.

Bernard E. Speranza ☼, a metallurgical engineer with General Electric Co.'s chemical and metallurgical training program, has joined the Carboly Department of General Electric Co. as an engineer in the carbide materials development section.

James M. Lommel ☼, a June graduate of Illinois Institute of Technology, has been awarded first prize in the annual undergraduate essay contest sponsored by the Chicago section of the American Institute of Mining and Metallurgical Engineers. Mr. Lommel received his degree in metallurgical engineering and will do graduate work at Illinois Tech this fall under a fellowship awarded by the Allegheny-Ludlum Steel Corp., Brackenridge, Pa.

John W. Pennington ☼ has been named manager of the new technical department of the Metal Products Division of Koppers Co., Inc., Pittsburgh. Mr. Pennington joined Koppers in 1950 as chief engineer of the Division's piston ring department, and since 1952 has held the post of executive engineer for the entire Metal Products Division. His new responsibilities will include the supervision of all research and development activities for all product departments of the division as well as liaison with Koppers' central research organization.

Gordon H. Gillis ☼, formerly superintendent of heat treating at Kropp Forge Ordnance Co., Melvindale, Mich., has joined the Carboly Department of General Electric Co. as a heat treating engineer for coal mining tools in the carbide process and development section. Mr. Gillis is a metallurgical engineer from Missouri School of Mines.

Charles A. Cincilla ☼, a June graduate of Lafayette College with a B.S. degree in metallurgical engineering, is now employed as metallurgist at the central foundry division of General Motors Corp. at Defiance, Ohio.

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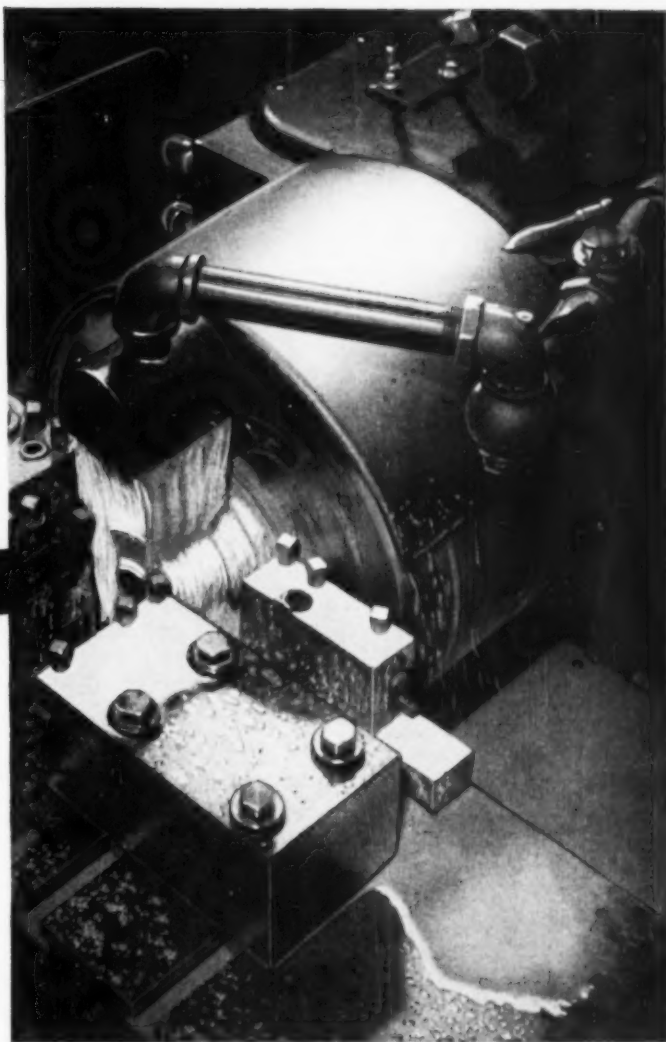
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TRIAL 2 OPERATION: Drilling, counterboring and reaming 90MM Projectiles, A.I.S.I. 1055 forgings

Dasco Performance: Number of pieces per set of tools averaged 250 for a rich mixture of competitive heavy duty soluble oil. A 1-20 mixture of Dasco Super Soluble Base produced 500 pieces per set of tools.

TRIAL 3 OPERATION: Internal grinding of steel ring

Machine: Bryant Internal Grinder

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Personals

Donald K. Tautz ☼, having received a master's degree from the California Institute of Technology, has accepted a position with the California Research Corp., La Habra, Calif.

John O'Connor III ☼ has been named assistant sales manager of the Cleveland district office of the Copperweld Steel Co., Warren, Ohio, division.

Walter Grunden, Jr. ☼, formerly metallurgical laboratory supervisor of Perfect Circle Corp., New Castle, Ind., has assumed the duties of project metallurgist.

William A. Geisler ☼ has joined the staff of Lester B. Knight & Associates, Inc. Mr. Geisler has had 26 years' foundry operating, research and development experience in the United States and Germany, and is the author of a number of papers delivered in this country, England and Germany.

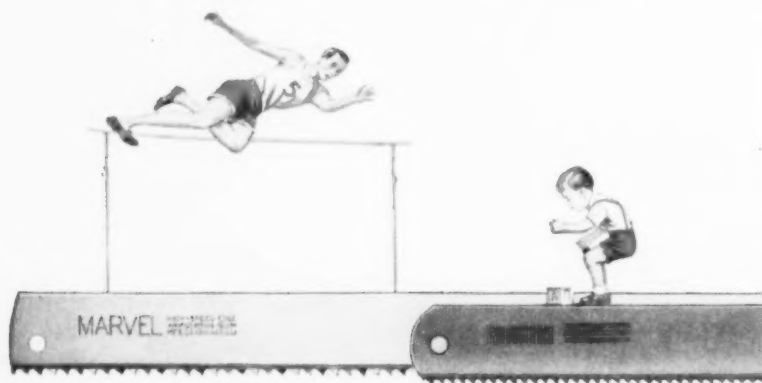
Willis Schalliol ☼ has joined the staff of Northern Indiana Brass Co., Elkhart, Ind., as manager of branches. Mr. Schalliol was formerly a supervisor of new fuel element development at General Electric Co.'s Hanford Atomic Products Operation, Richland, Wash.

D. C. Sanford ☼ has been appointed manager of the application engineering department of the Bristol Co., Waterbury, Conn. Mr. Sanford joined the company's sales engineering organization in 1937 and was promoted to Birmingham district manager in 1946. In 1948 he became an application engineer with headquarters at the company's main office in Waterbury, where he will remain.

Reinhardt Schuhmann, Jr. ☼ has been appointed professor of metallurgical engineering in the School of Chemical and Metallurgical Engineering of Purdue University, beginning with the second semester of the 1953-54 academic year, and will be chairman of the division of metallurgical engineering in the school. Dr. Schuhmann is now associate professor of metallurgy at Massachusetts Institute of Technology and has been at that institution since 1935. He holds degrees from the Missouri School of Mines, Montana School of Mines, and Massachusetts Institute of Technology. Professor Schuhmann is the author of the textbook "Metallurgical Engineering," and numerous technical articles.

C. W. Windfelder ☼, formerly manager of the Carpenter Steel Co.'s Milwaukee mill branch warehouse, has been appointed assistant to the vice-president and will continue to be located in Milwaukee. **W. J. Stephens** ☼ has been promoted from sales engineer to manager of the St. Louis branch of the Carpenter Steel Co.

A. L. Thurman ☼ has been appointed executive vice-president of Mannesmann-Meer Engineering and Construction Co. after 7 years of mill machinery experience with Aetna-Standard Engineering Co. Prior to that time he was with the General Electric Co. for over 8 years, the last five years of that period having been spent as a steel mill application engineer in the G.E. steel mill division. Mr. Thurman's headquarters are in Easton, Pa.



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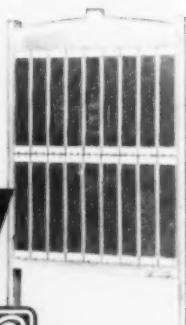
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Personals

John F. Richards ⚙, formerly employed as metallurgist for Simonds Saw & Steel Co., Lockport, N.Y., is now engaged as metallographer in the atomic energy division of Sylvania Electric Products Co., Bay-side, L.I., N.Y.

Alfred E. Stone ⚙ is in charge of the new sales and service division of Ipsen Industries, Inc., in Plainfield, N.J.

Newell Hamilton ⚙, formerly superintendent of the steel mill of the Babcock & Wilcox Co., Beaver Falls, Pa., has been appointed manager of steel operations in the tubular products division of the company. Mr. Hamilton has been with the Babcock & Wilcox Co. since graduating from Massachusetts Institute of Technology with his M.S. degree in physical metallurgy in 1928, and has been responsible for the development of several new alloys introduced by the division and their application to industrial uses.

Robert B. Clapper ⚙ has joined Dow Chemical Co., Midland, Mich., as development and research engineer in the design section of the metallurgical laboratories.

Felix Kremp ⚙, after 2½ years on leave from Crucible Steel Co. of America to serve as chief of the tool-steel section, iron and steel division of the National Production Authority, has returned to company duties. Mr. Kremp is product manager for tool and specialty steel produced at the Park Works, with headquarters in Pittsburgh.

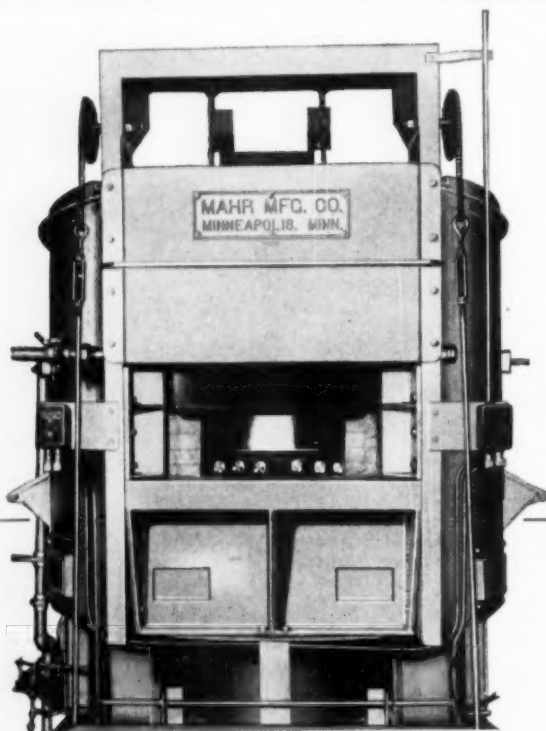
Norman W. Johnson ⚙, who was formerly with the major appliance division of General Electric Co., is now a principal metallurgical engineer at Battelle Memorial Institute, Columbus, Ohio.

Edward H. Platz, Jr. ⚙, manager of alloy sales, Lebanon Steel Foundry, Lebanon, Pa., was appointed chairman of the public relations committee of the Alloy Casting Institute. Assisting Mr. Platz on the committee is **C. M. Ruprecht** ⚙ of the Electro-Alloys Division of American Brake Shoe Co., Elyria, Ohio. The committee is active in promoting and furthering continued research in the production of both corrosion and heat resistant stainless steel alloys, and its function is to work closely with research and development at Ohio State University, Massachusetts Institute of Technology and Battelle Memorial Institute.

Hans W. Wawrousek ⚙ has been awarded an Allegheny Ludlum Graduate Fellowship in the department of metallurgical engineering at Rensselaer Polytechnic Institute. Mr. Wawrousek received his bachelor of science degree from Rensselaer in 1951 and his master's degree in 1953, both in metallurgical engineering.

James H. Bly ⚙ has been appointed research director of X-Ray Incorporated, Detroit, after a 13-year tenure with Pratt & Whitney, East Hartford, Conn.

Ross B. Hopkins ⚙ has been appointed plant metallurgist for Rodney Metals, Inc., New Bedford, Mass. Mr. Hopkins, a graduate of Case Institute of Technology, has been associated with American Steel & Wire Co. for the past 13 years.



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vacuum space — the entire unit enclosed in a stainless steel casing. Copper contributes ductility and malleability for spinning into hemispheres, unexcelled soldering properties for joining into spheres, and a mirror finish to reduce radiation losses. Need we tell you that it's made of ANACONDA Copper?



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The "High Iron" we're referring to is the HOBBYLINE HO-GAGE model railroad track which John A. English & Co. of Morrisville, Pa., makes of FORMBRITE[®] strip. This fine-grain, yet ductile forming brass

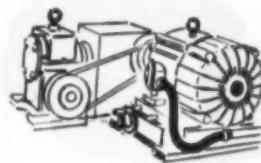
produces a track so strong and stiff it will support an adult's weight. In products where finishing costs count, users find that FORMBRITE usually needs only a color buff to produce a high finish.



Flexible conduit enjoys a splash in a bath

The real trick is to make an electrical conduit that's flexible and liquid-tight and approved by Underwriters' Laboratories for such applications. SEALTITE[®] Type UA does all three. Made with a tough syn-

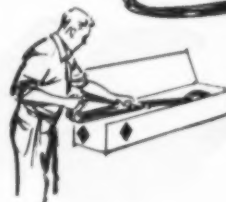
thetic jacket extruded over a flexible steel core, it's shown here protecting wiring to motor in an auto laundry. It ignores not only splashing, but also oil and grease, and resists abrasion. Want more facts?



We put an end to "the bends"

We don't mean the kind deep-sea divers suffer from, but the kind heating contractors had to put up with when they installed radiant panel heating systems. Heretofore, many contractors formed the panel grids on the job by hand-bending them from coils of tubing—a time-consum-

ing, laborious, back-breaking job. Now PG's[®] have ended all that. They are the new, compactly packaged, accurately pre-formed ANACONDA Copper Tube Panel Grids . . . from the handy carton to installation is only a matter of minutes. PG's are another ANACONDA first.



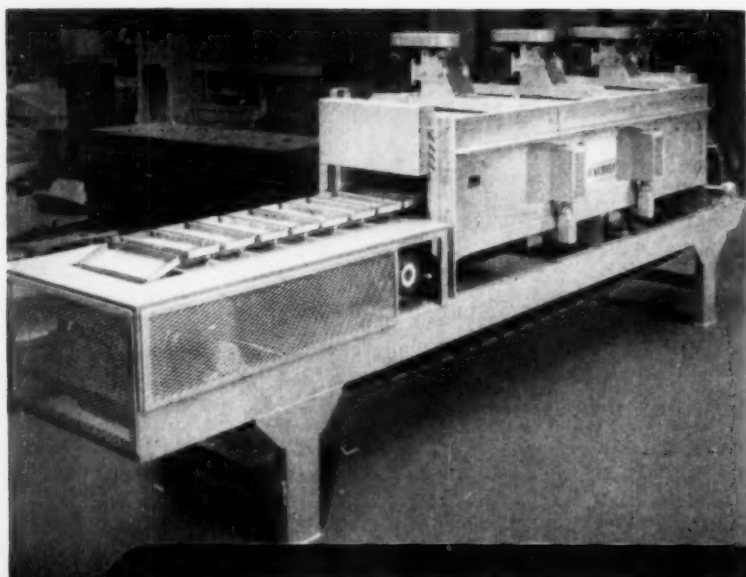
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Our Technical Department has a range of experience that covers the entire field of copper and copper-alloy applications in industry. If you have a problem of metal selection, we are at your service. *The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.*

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Of special design for Kohler Co. of Kohler, Wisconsin, this Hevi Duty Conveyor Furnace is being used to heat aluminum and brass billets prior to forging jet engine and other parts. Not only has this furnace been designed for a specific job, but Hevi Duty Engineers also built into this furnace many additional features.

- Notice the three fans which speed the heating of the billets by circulating the heated air, and also assure a uniform temperature in the heating chamber. With this feature, a smaller, more economical furnace is able to do this production job.
- Heat resistant alloy conveyor links and trays mean years of dependable service.
- Versatility . . . by using a variable speed drive to adjust the conveyor speed, this furnace can be used for annealing, tempering, and other heating operations.

Special Hevi Duty Furnaces can be engineered to your specifications and your production system. Let us know your requirements. Our engineers will work with you.

HEVI DUTY ELECTRIC COMPANY

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Heat Treating Furnaces... Electric Exclusively
Dry Type Transformers Constant Current Regulators

Personals

Sam Tour ☼ has been elected president of the Metal Science Club of New York. Mr. Tour, a consulting metallurgist with 30 years' experience in the field, is manager of Sam Tour & Co., Inc., New York. Howard S. Avery ☼ of the American Brakeshoe Co. was elected vice-president of the Club, and John P. Nielson ☼, professor of metallurgy at New York University, was elected to the post of secretary-treasurer.

Robert Maddin ☼, associate professor at the John Hopkins University School of Engineering, is to spend 1954 as visiting lecturer in metallurgy in the department of metallurgy at the University of Birmingham, England.

Carl R. Anderson ☼, formerly staff metallurgist, has been promoted to the position of assistant superintendent of the extrusion plant at the Lafayette Works of the Aluminum Co. of America in Lafayette, Ind.

Edward P. Rowady ☼ has completed the work in the chemical and metallurgical program of General Electric Co. and has been assigned to the laboratory unit of the company at the Allegheny Ludlum plant in Brackenridge, Pa., as a development metallurgist.

W. W. Sellers ☼, formerly staff metallurgist at the Peoria, Ill., plant of the Caterpillar Tractor Co., is now quality control manager for the York, Pa., plant.

William W. Berkey ☼, who was senior instructor in the metals technician branch of the department of crafts and trades training at Chanute Air Force Base, Ill., is now metallurgist in the research and development laboratory of the Reynolds Metals Co., Richmond, Va.

Howard W. Leavenworth, Jr. ☼ has been on the staff of the Franklin Institute, Philadelphia, as research metallurgist since graduating from Yale Graduate School of Engineering with an M.E. degree in metallurgy.

Robert C. Bates ☼, a graduate of the University of Utah in June with a B.Sc. degree in metallurgy, is now metallurgist in the application section in materials engineering, Westinghouse Electric Corp., Pittsburgh.

Louis Horvath ☉, a June graduate from Purdue University, is now with Bridgeport Brass Co. as assistant research metallurgist.

Roelof P. Steijn ☉ has resigned as assistant professor in mechanical engineering at Rice Institute, Houston, Texas, to accept a position as research metallurgist with the solid state physics group of the Franklin Institute, Philadelphia.

Lt. Raymond F. Decker ☉, who has been stationed at Watertown (Mass.) Arsenal as metallurgical engineer in the foundry, has been ordered to overseas duty in Europe.

John A. Fellows ☉, who has been associated with the American Brake Shoe Co. in metallurgical research since 1934, with time out during the war on assignment with the Manhattan Project, is now chief staff metallurgist for Mallinckrodt Chemical Works, St. Louis.

Robert J. Morris ☉ has resigned his position with the P. R. Mallory Co., Indianapolis, to enroll as a graduate student in metallurgy at the University of Cincinnati.

Harold P. Weinberg ☉ is now a materials engineer in the Research and Evaluation Division of the U.S. Naval Gun Factory, Washington, D.C.

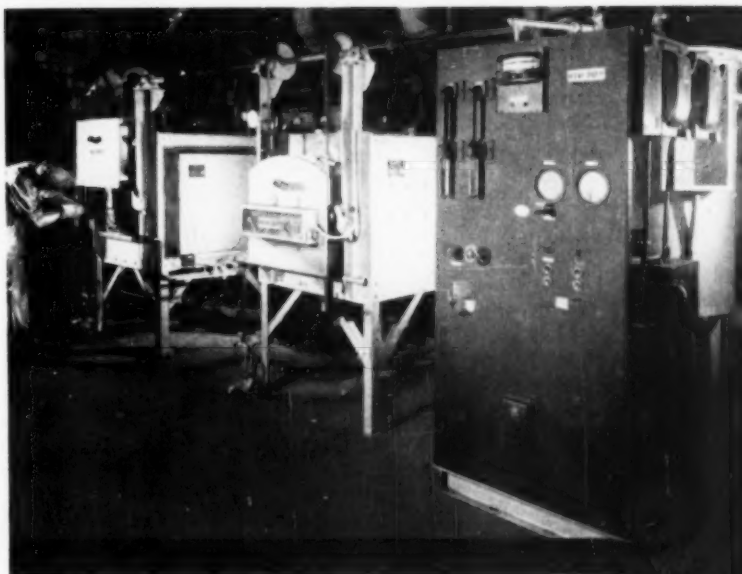
Michael A. Malachyn ☉ is employed as a sales engineer for the A. F. Holden Co., Detroit, covering the state of New Jersey, with headquarters in New Haven, Conn.

Russell A. Bain ☉, formerly with the Harvey Machine Co., Torrance, Calif., is now a research engineer at the Los Angeles plant of North American Aviation, Inc.

Nobuo Abe ☉, formerly manager of technical research department of Sunitomo Metal Industries, Ltd., Osaka, Japan, has been made chief engineer of the same company and is temporarily stationed in New York.

C. R. Sibley ☉ has been granted the Chicago Bridge and Iron Co. Fellowship at Rensselaer Polytechnic Institute, Troy, N.Y., and is now enrolled in the graduate school of metallurgy.

Paul E. Fedeles ☉ is employed as metallurgist for Latrobe Steel Co., Latrobe, Pa.



Tools and Dies Heat Treated in...

HEVI DUTY® Controlled ATMOSPHERE FURNACES

Allis Chalmers of Milwaukee is using Hevi Duty Controlled Atmosphere Furnaces to heat treat tools and dies made from high carbon, high chrome steels, 18-4-1, molybdenum, and cobalt high speed steels. Maintaining the exact surface carbon content of the tools and dies during heat treating is achieved with —

- A Hevi Duty Endothermic Atmosphere Generator supplying 500 cubic feet per hour of prepared atmosphere. With this controlled atmosphere, troublesome scale and decarburization or carburization of the surface is eliminated.
- A Hevi Duty Box Type Hardening Furnace, designed for temperatures to 2000° F., is used for preheating high speed steels and hardening carbon steels.
- A Hevi Duty High Temperature Furnace, designed for temperatures to 2600° F., is used to harden the high speed steels.

This combination assures you that tools and dies can be treated to exact hardness. Achieve better heat treating results by specifying Hevi Duty Furnaces. Write for Bulletin 153.

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Heat Treating Furnaces... Electric Exclusively
Dry Type Transformers Constant Current Regulators

Diffusion Coatings*

MOST of the various processes available for the surface treatment of metals and alloys utilize the mechanism of diffusion. Even electroplated and metal-sprayed coatings are often given a diffusion heat treatment to improve properties. However, it is with processes that involve a solid-gas reaction, such as in nitriding, carburizing and decomposition of a gaseous metal halide, that the principles of diffusion coating are most evident.

The speed of diffusion coating may

*Digest of "Diffusion Coatings", by D. M. Dovey, I. Jenkins, and K. C. Randle, *Journal of the Institute of Metals*, Symposium on Properties of Metals, 1952, p. 213-236.

be limited by the available supply of coating material at the base-metal surface, which frequently happens when plating from the vapor phase, or by the rate of diffusion into the metal base. Such a rate is difficult to calculate from simple laws of diffusion, since more than one phase is often present and small impurities in the base metal may have a strong effect. Thus, in the chromizing of steel, the addition of titanium to the steel greatly accelerates this rate of diffusion, whereas the presence of carbon acts as a retardant because of the formation of chromium carbide at the coating-core interface.

Deposition of metals by decomposition of a volatilized halide is a convenient method for many metals that are not easily deposited by other

means. The mechanism may be one of metal replacement, of thermal decomposition, or of catalytic reduction (as by hydrogen) at the surface of the base metal. Using thermodynamic data for the metal chlorides, or other halides, one can calculate which of these reactions may occur, or if a combination is possible. Many iodides, carbonyls, and hydrides can be made to deposit by thermal decomposition alone.

In reviewing case hardening means, attention is called particularly to carbo-nitriding and its advantages in producing shallow cases having high hardness and good wear resistance. Although the mechanism of the process is not thoroughly understood, a necessary feature appears to be the securing of a higher diffusion rate of nitrogen than of carbon in the austenite-ferrite matrix. In gaseous carbo-nitriding, maximum hardness occurs slightly below the surface.

Siliconizing steel by both Ihrig's method and from a hydrogen-silicon tetrachloride mixture leaves much to be desired, although rates of deposition are higher than for chromizing. A 5% hydrogen-nitrogen carrier gas gave a good coating on mild steel, but unsatisfactory coatings were obtained on medium, high-carbon, or alloy steels. (Successful gaseous siliconizing depends on some factors not well covered in this paper, and its eventual field of application may be wider than the authors have indicated.) A promising field for siliconizing is in the protection of molybdenum from high-temperature oxidation. Also, molybdenum can be protected by hot dipping in an aluminum-silicon alloy bath, and heating to convert the film to a ceramic form like mullite or sillimanite. The deposition of refractory coatings by diffusion coating from the vapor phase constitutes an important new field, since so many combinations of metals, nitrides, carbides, borides, silicides, oxides and alloys can be so formed.

Diffusion coatings are of future importance not only in protecting the surface of a base metal against corrosion, oxidation or wear, but also in effecting economy in the use of scarce or expensive metals. Chromized low-alloy steels are being used in domestic appliances, in the food-processing industries, and for engineering components to pro-

(Continued on p. 124)



Features of
**Siliconized
WITCH OIL**

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Preventative
Supreme*

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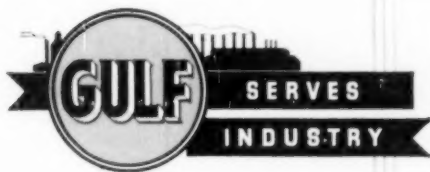
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we get better finishes, longer tool life
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COMPARE these Scarfing Rings used in the tip of a Gas Torch . . .



KENTANIUM Ring
after
1,960 HOURS

SUPER-ALLOY Ring
after
162 HOURS

There's no sign of wear on the Kentanium ring and it's still on the job . . . after 1,960 hours (80 days) of service! Compare this performance with that of the super-alloy ring that had broken down from thermal shock, abrasion, and oxidation after only 162 hours . . . a better than TEN to ONE record in favor of Kentanium. This is a typical example of how industry is effectively using heat-resistant Kentanium.

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If you need a material having long service life at elevated temperatures, investigate Kentanium . . . an exclusive development by Kennametal. It is a titanium carbide base composition.

Kentanium resists thermal and physical shock, withstands abrasion and oxidation, and retains great strength at 1800°F and above. It weighs only $\frac{3}{4}$ as much as steel; is up to 93 RA in hardness.

Many grades of Kentanium are available to meet combinations of specific conditions. A wide variety of simple or complex shapes can be produced, to meet your specifications. Ask our engineers to recommend how you can best apply this remarkable, new heat-resistant material.

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HEAT-RESISTANT, HIGH-STRENGTH, LIGHTWEIGHT
CEMENTED TITANIUM CARBIDE

SALES OFFICES IN PRINCIPAL CITIES

3-45

Diffusion Coatings

(Continued from p. 122)

tection against room-temperature corrosion or elevated-temperature oxidation. An alloy coating of chromium and aluminum is preferred for applications over 1470° F. A chromized steel can be electropolished as well as polished mechanically. Siliconized coatings may find applications in combining corrosion resistance with wear resistance, as for the oil, chemical, and paper industries. Much remains to be done in the laboratory to gain information on effect of phase changes and other factors on diffusivity and on properties of diffusion coatings which have already shown their usefulness.

Although little new work is reported in this paper, it is an excellent review and discussion of this important field of metallurgy.

BRUCE W. CONSER

Compression-Creep Machines for Elevated Temperatures*

THE COMPARISON of creep in compression with that in tension and the study of the initiation of third-stage creep and fracture have prompted the need for equipment to carry out compression-creep tests at high temperature with a precision similar to that normally obtained in tensile creep tests. The advantage of the compression test is that far less material is required for specimens. This factor prompted the metallurgy division of the National Physical Laboratory to design a compression-creep machine which was further developed in the Fulmer Research Institute.

The equipment consists of loading frames which can be accommodated in the loading shackles of a standard tensile-creep machine. The heavy upper loading frame, supported by the upper loading shackle of a tension-creep machine, contains an axial loading guide for the upper and lower specimen adapters while the lower framework, attached to the

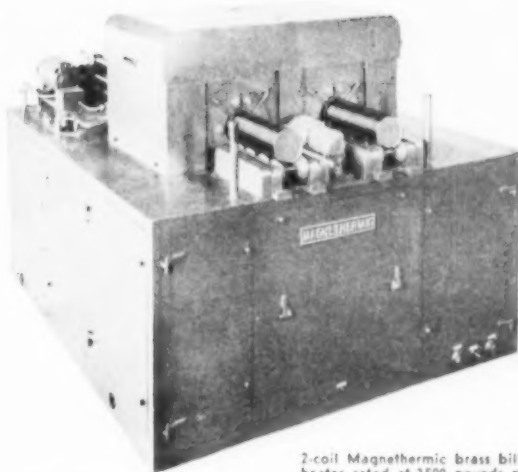
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*"Digest of Equipment for Compression-Creep Tests at High Temperatures", by A. E. Johnson and N. E. Frost, *Engineering*, Vol. 176, July 3, 1953, p. 28-29.

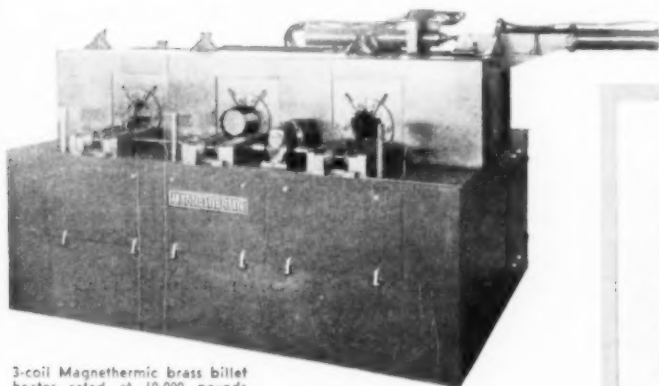
Induction Heaters for Brass and Copper Billets

REDUCE OPERATING COSTS

Magnethermic 60-cycle brass and copper billet heaters, now in operation, prove that they do reduce operating costs. Billets are heated in two or three minutes rather than hours. Temperature control is extremely accurate . . . each billet is discharged at exactly the same temperature. No warm-up time is required. On initial start ups, press the button, and in two or three minutes, heated billets are ready for further processing. No need to schedule billets ahead of time. Not more than three billets are in process at any one time.



2-coil Magnethermic brass billet heater rated at 2500 pounds per hour.



3-coil Magnethermic brass billet heater rated at 10,000 pounds per hour.

MAINTENANCE

Furnace damage is caused by heat. In a typical Magnethermic heater, the heating chamber is a tube 8" in diameter, 24" long, and water cooled for long life. In a conventional furnace, the heating chamber may be 40 ft. long, 8 ft. wide and 3 ft. high. It stands to reason that the latter will require many times the maintenance that the induction coil requires. Then too, no need to shut down when relining the coil. Operate on the other coils, or put in a spare coil. Coils can be changed in ten minutes and relined in an hour or two.

ALL SIZES

Magnethermic makes a single, two, or three-coil heater for any production requirement needed. All heaters are shipped completely assembled. Installation cost is at a minimum. Working conditions are ideal and floor space is negligible.

Heaters will operate equally well on extrusion billets, piercer billets, or wire bars. If you have a heating problem, let one of our engineers discuss it with you. A letter or phone call will receive prompt attention.



FIRST with MECHANIZED Batch Type Heat Treating



➡ **Normal Oil Quenching**

➡ **Hot Oil Quenching**

➡ **Slow Cooling In Atmosphere**

➡ **Atmosphere Quenching**

➡ **Isothermal Annealing**

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Compression-Creep Machines for Elevated Temperatures

(Continued from p. 124)

lower loading shackle, is simply a rectangular frame which sits on a hardened steel ball at the top of the upper specimen adapter. Since the specimen adapter is axially guided and the load is transmitted through the ball joint, axial loading is obtained with freedom from sideways thrust.

The furnace is located within the two frameworks and encloses the specimen, the specimen adapters, and a spherical seat. The spherical seat located at the upper end of the specimen is made of Stellite while the adapters are made of Nimonic 80 alloy.

The furnace capable of attaining temperatures up to 1290° F. is split longitudinally. The winding is tapped to facilitate adjustment of the specimen gradient to within 3.5° F. A platinum resistance thermostat maintains temperature to $\pm \frac{1}{2}^{\circ}$ C. (0.9° F.).

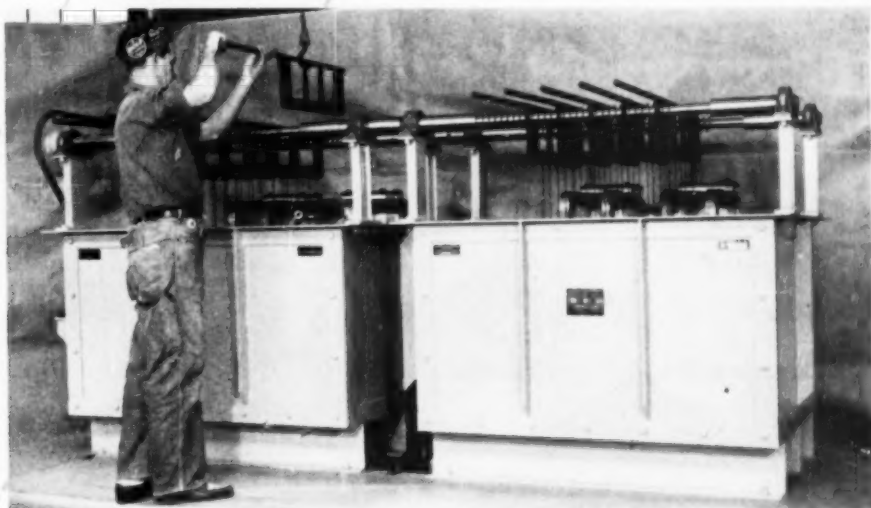
The standard specimen is 0.357 in. diameter and 1 in. long. Limitations are imposed on the diameter; it must be large enough to prevent buckling and small enough to minimize end effects. The ends of the specimen are flat (no special features have been incorporated but the frictional forces are minimized by applying a graphite coating).

The extensometer rods are attached to the specimen adapters at the specimen ends and extend downward out of the furnace. Rhombs carrying mirrors are placed between the rods on each side of the specimen and the strains are measured with a telescope. This is similar to that used in tension tests. Increments of strain of the order of 10^{-6} can be measured. Although the extensometer rods are not attached directly to the gage length, very little error is encountered since the stress in the end pieces is kept very low. This factor, however, limits the maximum working temperature to about 1290° F.

This equipment can also be used for short-time compression tests and for the determination of modulus in compression. M. J. MANJOINE

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Houghton Liquid Salt Baths cover a temperature range of 350° F. to 2400° F. for drawing, martempering, annealing, quenching, carburizing, nitriding, normalizing and hardening of both ferrous and non-ferrous metals.

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Liquid salts bring parts up to heat faster than is possible by radiation because the thermal conductivity from salt to metal is much higher than from air to metal. And because all atmosphere is excluded from the metal, decarburization and other surface problems do not occur and following surface treatment is not necessary.

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Because temperatures of liquid salts can be controlled within two to three degrees, you can get the same close tolerances in your heat-treating as you demand from your machine shop. And you can get it batch after batch, week in and week out because Houghton Liquid Salt Baths are pure and double-refined for stability.

Ask your Houghton Man about Salt Bath Heat Treatment—he's had a lot of experience in servicing salt baths and will be glad to help you, too. In the meantime, write for your copy of Houghton's Liquid Salt Bath Catalog. E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, Pa.

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Ready to give you
on-the-job service ...

Study of Carbo-Nitriding of Boron Steels*

NUMEROUS PUBLICATIONS governing the use of boron-treated steels have appeared during the period of boron substitution for critical alloys. The papers have dealt with carburized hardenabilities, plain hardenability studies, as well as the mechanical properties and service behavior of boron-treated steels. Although carburized boron steels have received attention in the literature,

little has appeared on the carbo-nitriding of these steels until the appearance of this paper.

In their investigation the authors employed A.I.S.I. 1020, 80B20, 94B17 and a proprietary steel "Superkore AA" containing boron. Subsequent to normalizing, these steels were case hardened using a carrier gas enriched with methane; for carbo-nitriding the carrier gas was enriched with methane and ammonia. All carburizing was done at 1700° F. for 3 hr. with an atmosphere containing 95% carrier gas plus 5% methane. The carbo-nitriding

was done at 1500, 1600 and 1650° F. for 4 hr. with ammonia contents of 15% at 1500° F., 10% at 1600° F. and 5% at 1650° F., plus 5% methane, the balance being carrier gas.

For the hardenability studies, carburized and carbo-nitrided bars were quenched by the standard procedure in the end-quench fixture. Results from these tests showed an increase in surface hardenability for the carbo-nitriding treatment. Jominy distance at Rockwell A-75 was 3/16 in. for the bar carburized at 1700° F., whereas the distances for carbo-nitrided bars were 11/16 in. for 1650° F., 12/16 in. for 1600° F. and 14/16 in. for 1500° F. Although smaller quantities of ammonia were used at the higher temperatures, a considerable increase in hardenability resulted. This increase in hardenability, the authors point out, is caused by the uncombined nitrogen in the case.

When these tests were repeated using boron steels, the carbo-nitrided bars were lower in hardenability than the carburized bars. Jominy distances at Rockwell A-75 for 94B17 were 10/16 in. for the 1700° F. carburized bar and 6/16 in. for the 1600° F. carbo-nitrided bar. The same hardness on 80B20 was obtained at 8/16 in. for the carburized and 5/16 in. for the carbo-nitrided bars. Again the authors refer to the nitrogen, contending that nitrides are precipitated in the boron steels which in turn nucleate the formation of pearlite and cause a reduction in hardenability. They contend that the low hardenability of the carbo-nitrided boron steels can be attributed to the interference of nitrogen with the action of boron.

Along with the hardenability samples, the authors ran 1/8-in. square specimens for microhardness testing with the Knoop machine, these tests being through the cross-sectioned carbo-nitrided case. Results from these microhardness studies show that the maximum case hardness of 86B20 and "Superkore AA" is of the same magnitude as published data on conventional alloy steels, but that of the 94B17 is lower.

R. D. CHAPMAN

*Digest of "The Carbo-Nitriding of Boron Steel", by G. W. Powell, M. B. Bever and C. F. Floe, © 1953 Preprint No. 23.

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there's tough hot
work to do!**



Of all the many types and shapes of steel that make Jessop America's most diversified specialty steel house, none shows its quality in the clinches better than the DICA-B brand hot work steel illustrated here in the form of a die. Jessop is justly proud of this steel because its high quality is easy to measure. For example, if you make dies, knives, punches or tools for any type of die-casting, forming, punching, cutting or extruding of hot ferrous or nonferrous metals, Jessop has a steel for you. Jessop has a carefully controlled analysis to give you extra toughness to resist shock, or extra hardness to withstand abrasion, or extra ability to resist temperature change without checking or cracking—or any combination of these virtues. And beyond matchless quality, the fast, efficient service of the Jessop team will please you no end. To find this out very quickly, send us an order for any of the specialty steels listed here.

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HEAT RESISTING CASTINGS
COMPOSITE
DIE STEEL SECTIONS
PRECISION GROUND
FLAT STOCK
DIE STEELS—
HOT AND COLD WORK



JESSOP
STEEL COMPANY • WASHINGTON, PA.

The advertisement features a large central photograph of a massive industrial press platen in a factory setting, with workers visible in the background. To the left of this central image is a vertical column of seven smaller photographs showing various fabricated steel components, including a rectangular box with multiple openings, a long rectangular frame, a square box with circular cutouts, a rectangular frame with a circular opening, a large circular flange with multiple bolt holes, and three small cylindrical components. Below the central photograph is a circular inset showing two workers in a workshop setting. The text 'Steel-Weld FABRICATION' is written in a large, stylized script across the top of the central image. A diagonal banner across the middle of the advertisement reads 'Use WELDED STEEL for Greater Strength with Less Weight!'. The company name 'THE R. C. MAHON COMPANY' and its location 'DETROIT 34, MICHIGAN' are printed in a bold, sans-serif font. Below this, a black banner contains the text 'Engineers and Fabricators of Steel in Any Form, for Any Purpose'. The company name 'MAHON' is printed in large, bold, white letters at the bottom of the advertisement.

Steel-Weld FABRICATION

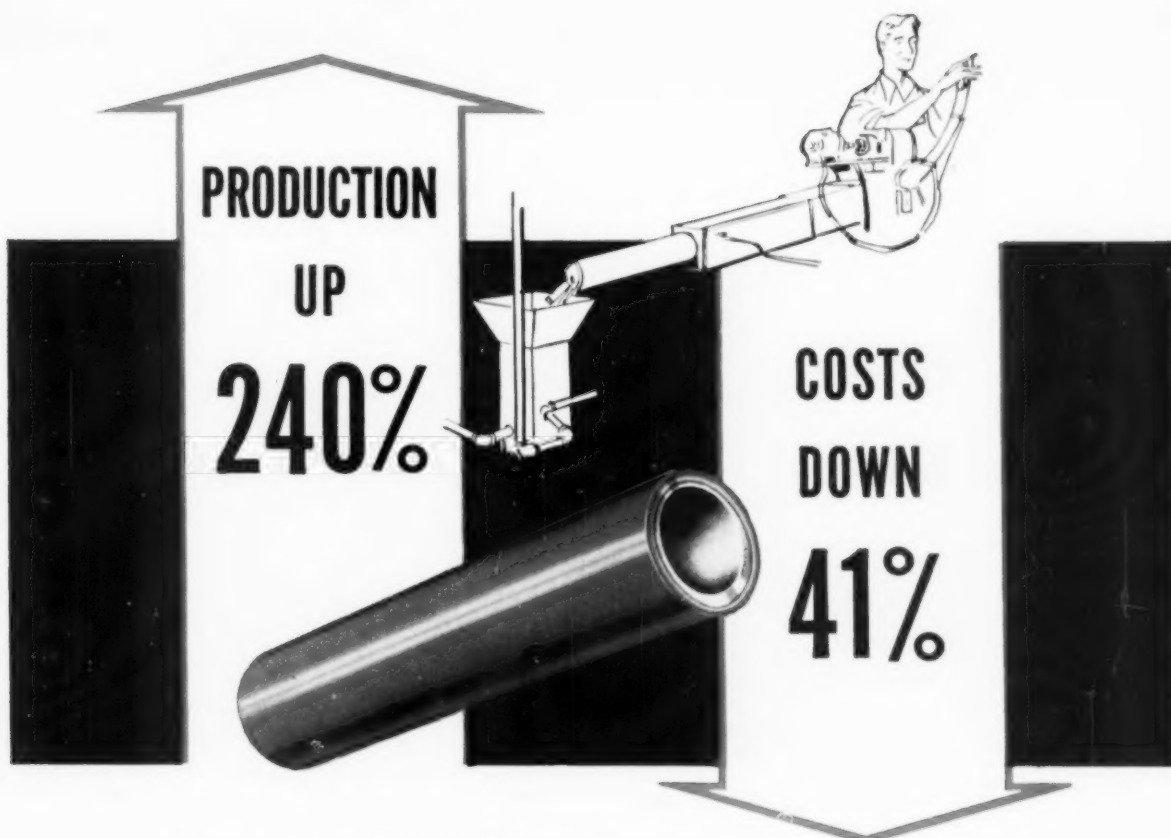
Use WELDED STEEL
for Greater Strength
with Less Weight!

The forty ton Press Platen above, and the parts and assemblies illustrated at the left, are typical of thousands of Steel-Weld Fabricated units produced and machined by Mahon for hundreds of manufacturers of heavy machines and other mechanical equipment. If parts of your product could be re-designed and produced to better advantage through Steel-Weld Fabrication, or, if you require a limited number of large heavy pieces in which pattern costs are a consideration, you can turn to The R. C. Mahon Company with complete confidence . . . personnel and facilities are available within the Mahon plant to do the complete job from drawing board to finished machining. You will find in the Mahon organization a unique source with complete ultramodern fabricating, machining and handling facilities to cope with any type of work regardless of size or weight . . . a source where skillful designing and advanced fabricating technique are supplemented by craftsmanship which assures a smoother, finer appearing job embodying every advantage of Steel-Weld Fabrication. See Mahon's Insert in Sweet's Product Design File, or write for further information.

THE R. C. MAHON COMPANY
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Engineers and Fabricators of Steel in Any Form, for Any Purpose

MAHON



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Whether you're interested in upping production or downing costs—or both—it pays to investigate TOCCO Induction Heating if you heat-treat, anneal, braze, solder, forge or melt ferrous or non-ferrous metal parts.

PRODUCTION UP—When Thompson Products Ltd., St. Catharines, Ontario switched from conventional methods to TOCCO Induction Hardening of their automotive wrist pins, production rose from 500 to 1200 per hour.

COSTS DOWN—While production jumped, costs fell from \$5.46 per hundred parts to \$3.23—a savings of more than 2c per pin or \$26.76 per hour on the hardening operation alone.

OTHER ADVANTAGES—Additional savings result from elimination of hauling wrist pins to and from the heat-treat department. Cool, clean TOCCO fits right in the production line, next to related operations—takes only $\frac{1}{4}$ the space of the pusher-type furnace previously used.

In Canada or the United States TOCCO engineers are glad to survey your operations for similar cost-cutting results—no obligation, of course.

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Dept. R-12, Cleveland 1, Ohio

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IN TANKS—those rumbling, roaring monarchs of our Ground Forces—vital points are protected with armor castings made by Lebanon Steel Foundry. For the Detroit Arsenal alone, Lebanon has produced over 60,000 armor castings—principally ventilating grille louvre doors and corner hull brackets for the M46, M47 and the current M48 medium (General Patton) tanks.

As early as 1935, Lebanon Steel Foundry cooperated with Army Ordnance in the development of cast armor. In 1952 Lebanon received a citation for designing and casting top-quality louvre doors for the medium tank. The engineering and production skills of Lebanon craftsmen have ably contributed to practically every tank development and production program since cast armor became a reality.

See—STEEL WITH A THOUSAND QUALITIES—37 mil., 16 mm, semi-technical, full-color, sound film on the making of steel castings. For information write: Dept. H, Lebanon Steel Foundry.

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AND STAINLESS STEEL

LEBANON STEEL FOUNDRY



LEBANON, PA.

Cracking of Soft Steel Under Stress and Corrosion *

THIS very comprehensive paper describes the stress-corrosion cracking of mild steel plates when immersed in solutions of calcium nitrate (860 g. per l.) and ammonium nitrate (30 g. per l.) at 100C° (212 F.).

Ten different steels were studied: basic bessemer, rimmed and killed; basic openhearth, rimmed and killed with 0.08, 0.16, and 0.22% carbon; acid openhearth—in the form of hot rolled plate, 3/16 in. thick. Nitrogen contents varied from 0.003 to 0.013%. These combinations were selected after review of the literature on the stress-corrosion cracking of mild steels.

Various causes have been proposed: (a) absorption of hydrogen in the ferrite grain boundaries; (b) effect of stress concentrations at the bottom of cracks or pits; (c) locked-up stresses due to welding or other fabrication processes; (d) precipitation of some new phase such as iron nitride. Mr. Perkins' work indicates that none of these theories fully explain this phenomenon in mild steel.

The experimental procedure consisted of stressing 1-in. strips of the steels to different stress levels varying from 12,000 to 88,000 psi. in a special jig and then immersing them in the boiling nitrate solution. The time for cracking to develop was recorded for each stress level for each steel, and typical plots of the results are shown in the paper. Although none of the steels in the stressed, hot rolled condition cracked in the nitrate solution, most samples cracked if they had been previously cold strained (from 2% to 10%) prior to putting them into the test jig. The minimum stress then required to cause cracks varied widely for the different steels; the lowest stress was about 12,000 psi. for the bessemer rimmed steel and the highest was about 25,000 psi. for the acid openhearth steel. These stress values are based on a 50-hr. exposure. At

(Continued on p. 132)

*Digest of "Stress-Corrosion Cracking of Mild Steels in Nitrate Solution," by R. N. Perkins; *Journal of the (British) Iron & Steel Institute*, Vol. 172, 1952, p. 149-161.

VACUUM METALLIZING...

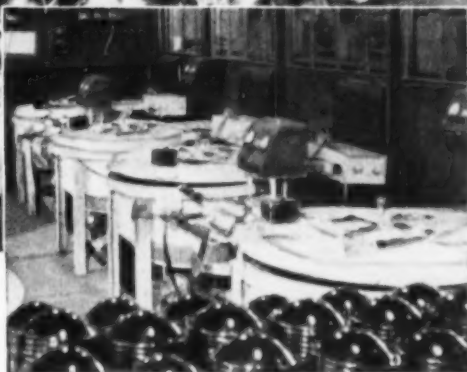
"More and more use is going to be made of this remarkable process", said exhibitors at the 1952 Metal Show.

"Working in a DRY atmosphere greatly speeds up pulling the vacuum", reports Canadian Motor Lamp Company.



THE PROCESS: Metal or plastic parts are placed in a sealed retort. A high vacuum is pulled and aluminum wire is vaporized by an electric current. This deposits on the parts, giving 85% reflective power, compared to 62% for polished aluminum.

THE PROBLEM: Moisture in the air and on the parts being metal coated slows down the pulling of a vacuum, cutting production and increasing costs.



THE SOLUTION: DRY the air with a Lectrodryer* as Canadian Motor Lamp Co., Ltd. do at their Windsor, Ont., plant. They report that it would be impossible to maintain their high production schedule and turn out such quality workmanship without this DRYing help.

Names of companies making equipment for this high vacuum coating of metals and plastics will be supplied to you on request. Where DRYing is indicated for the air surrounding this equipment, or for air supplied to their retorts,

Lectrodryer will work with them to give you most efficient, economical operation.

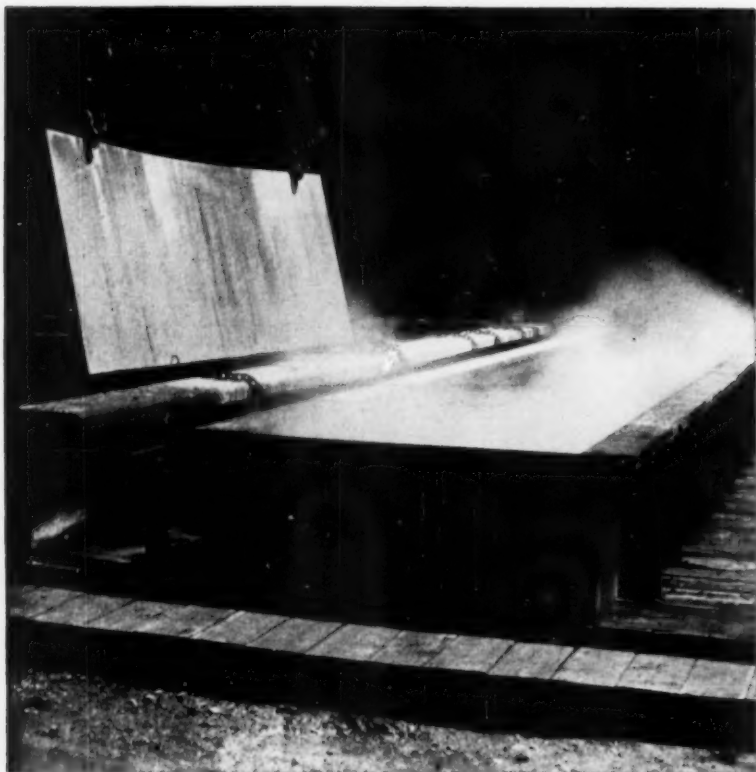
For further information, write to Pittsburgh Lectrodryer Corporation, 317 32nd Street, Pittsburgh 30, Penna.

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THESE TANKS ARE GETTING HOTTER ALL THE TIME . . .

Higher temperatures and the more highly concentrated pickling solutions now in use are accomplishing a far more economical and effective pickling job. At the same time, corrosive attack on the pickling vessel itself is accelerated by these stronger solutions. This has necessitated more critical consideration of pickling tank materials and constructions.

The Atlas Mineral Products Company has been the leader in furnishing materials for corrosion-proof pickling tank construction for over twenty years. Practically all the "big lines" and a large proportion of the small tanks are built with ATLAS materials. In furnishing acid-proof brick, corrosion-proof cements and vessel linings, not only has ATLAS kept ahead of the field technically . . . but stringent product quality control has been assurance that every batch has consistently maintained standards. Batch to batch variations could have costly results, and ATLAS has continuously guarded its customers against this possibility.

Success of a pickling tank installation is also dependent upon construction. And, for this reason, ATLAS maintains engineering facilities solely devoted to pickling tank design. In turn, these services are available to you locally through Atlas Sales Engineers in your community.



CORROSION-PROOF CEMENT DATA is provided in Bulletin 5-2. A copy will be sent to you gladly upon request.

ATLAS . . . corrosion-proof cements . . . coatings . . . vessel linings . . . plastic structures.



**ATLAS
MINERAL
PRODUCTS CO.**

MERTZTOWN, PENNSYLVANIA

Cracking of Soft Steel Under Stress and Corrosion

(Continued from p. 130)

higher stresses, each steel cracked more quickly.

These preliminary results indicated that method of manufacture (state of deoxidation) or chemical composition influenced the tendency for stress-corrosion cracking. Four of the steels, 0.18% carbon basic openhearth (rimmed), 0.18% carbon basic openhearth (killed), and 0.22% carbon basic openhearth (rimmed or killed) developed cracks in the cold worked, stressed condition only after long times (up to 2000 hr.).

The influence of low carbon content in decreasing the tendency of the stress-corrosion cracking was most significant. Since it had been observed by previous investigators that decreasing the carbon content below 0.003% and nitrogen below 0.0036% rendered the steel fairly safe, three of the steels (0.07% C rimmed bessemer, 0.18% C killed basic openhearth, 0.22% C basic openhearth) were annealed in wet hydrogen at 1325°F. for various times to obtain samples with different amounts of carbon and nitrogen. Many test pieces, after this annealing treatment, were cold strained 10% in the tensile machine, stressed, and immersed in the nitrate bath for various times. The low-carbon bessemer steel cracked in 10 to 40 hr. at carbon contents of 0.030 to 0.07%, but did not crack in 500 hr. when carbon was below 0.02%. The basic openhearth samples, which had carbon contents ranging from 0.03 to 0.16%, all cracked in 15 to 20 hr. The samples with more than 0.16% carbon and all samples with less than 0.02% carbon did not crack.

The author gives no details as to the relation between the nitrogen remaining after wet hydrogen annealing, and the cracking phenomenon. However, three steels were nitrified to 0.0035% and 0.096%. One steel was a 0.09% C bessemer grade with 0.007% initial nitrogen and two were basic openhearth steels with 0.18% and 0.22% carbon and initial nitrogen of 0.004%. Rapid cracking (less than 30 hr.) developed in all three steels when the

(Continued on p. 134)

**for Greater Strength
with Lighter Weight**
**in modern
material handling equipment**



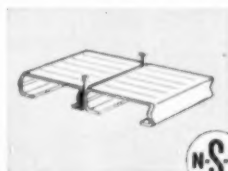
The increasing use of the Evans DF Loader reflects the progress of railroads toward more efficient material handling methods.

In the DF Loader there is high strength with minimum weight through the use of N-A-X HIGH-TENSILE steel. This low-alloy steel has 50% greater strength than mild carbon steel, with greater resistance to corrosion with either painted or unpainted surfaces.

You can get the same results as Evans. Your product can be made stronger, lighter in weight and longer-lasting, when you specify N-A-X HIGH-TENSILE steel.

THE EVANS DF LOADER is a product of Evans Products Co., Plymouth, Mich. DF means Damage - Free, Dunnage - Free.

NAILABLE STEEL FLOORING for boxcars, flatcars and gondolas is made of N-A-X HIGH-TENSILE steel, and is a product of Steel Floor Division, Great Lakes Steel Corporation.



Engineering data on these products available upon request to the manufacturers.

The "Wonder Bar," a section of which is shown at left, is a vital part of the Evans DF Loader. It is a wooden bar reinforced by a Z-bar made of N-A-X HIGH-TENSILE.

The "Wonder Bar," when locked into place, secures all kinds of lading. It is strong enough to resist shifting load stresses in moving boxcars, yet so light that one man can lift it into position. The DF Loader provides real operating economies for both railroads and shippers.

Another modern product for efficient transportation equipment is Nailable Steel Flooring, also made of N-A-X HIGH-TENSILE steel.

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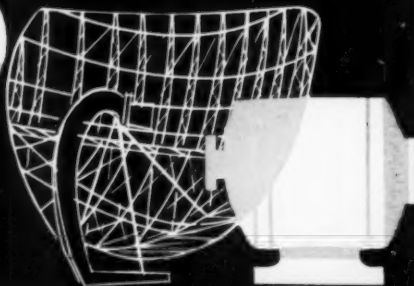
N-A X Alloy Division

Ecorse, Detroit 29, Mich.

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ON MAGNESIUM Iridite provides a highly protective film in deepening shades of brown. No boiling, elaborate cleaning or long immersions.

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Cracking of Soft Steel Under Stress and Corrosion

(Continued from p. 132)

nitrogen content was boosted to 0.050%, but no cracks in any of the steels were observed after 250 hr. immersion when their nitrogen exceeded 0.050%.

In a final experiment on the effect of nitriding on cracking susceptibility, samples of the 0.07% C bessemer steel were annealed in wet hydrogen to make them resistant to cracking and then nitrided to 0.095% N. (The carbon content was 0.015%.) Samples so treated showed no intergranular corrosion at any stress level after 300 hr. immersion in the hot test solution. Finally, a sample of high-purity iron (99.99%+) showed no cracking after 300 hr.

Microscopic observations indicated that the hot rolled samples with the higher carbons were very resistant to intergranular corrosion. The carbon was present in a normal pearlitic structure, intergranular corrosion on samples containing over 0.16% carbon were annealed at 1300° F. long enough to develop a spheroidized structure, intergranular corrosion occurred in very short times (1 to 100 hr.) depending upon the extent of spheroidization.

The results of other investigators, emphasizing that cracking occurs when a minimum stress is exceeded, and that previous cold plastic deformation is detrimental, have been confirmed. The tendencies to stress-corrosion cracking of these steels showed that the nitride precipitation theory is not generally applicable, and that the most important composition factor is associated with the carbon content and the structural distribution of the carbon; the cracking was found to be definitely related to the presence of cementite in ferrite grain boundaries. The author concludes as follows:

"A grain boundary is a region of inherent distortion, but the magnitude of the latter is increased when carbide particles are located in such regions and the material is cold worked. The ferrite in the region of the carbides will be distorted to a greater extent than elsewhere, owing to the presence of so-called

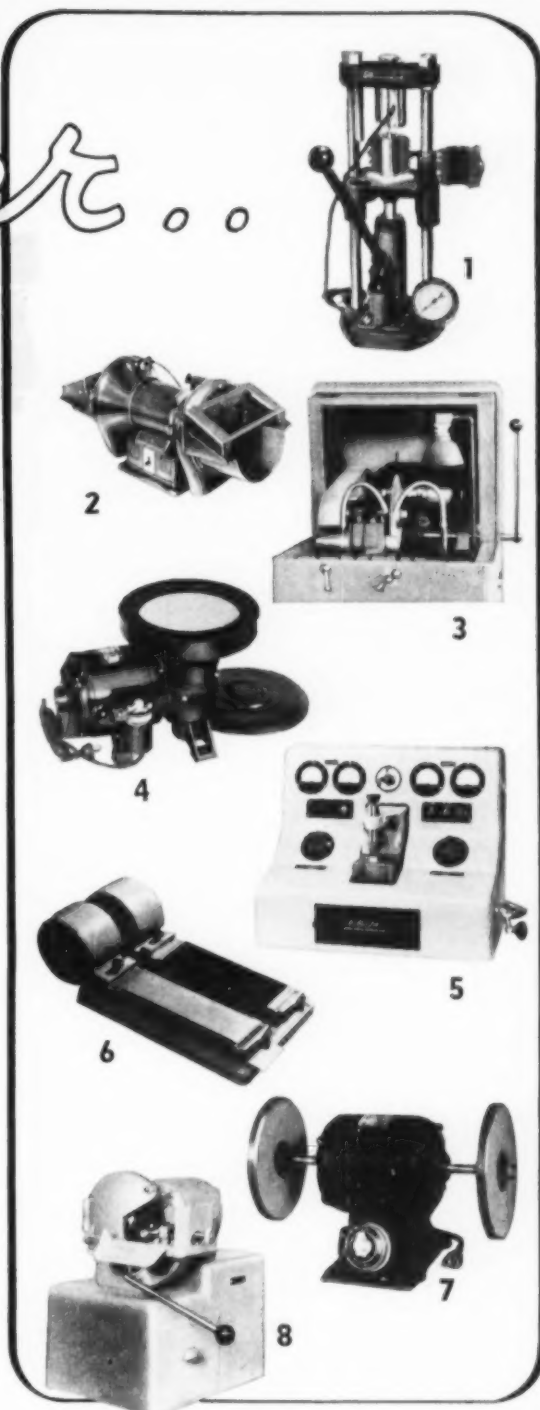
(Continued on p. 136)

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... OFFERS A COMPLETE LINE OF EQUIPMENT FOR THE Metallurgical Laboratory

Buehler specimen preparation equipment is designed especially for the metallurgist, and is built with a high degree of precision and accuracy for the fast production of the finest quality of metallurgical specimens.

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Buehler Ltd.

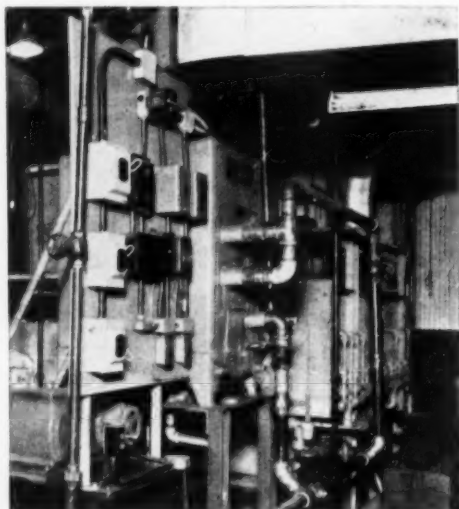
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Your Department can have a better arrangement with
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increases your production.

*This quench
bath cooler
gives you
control of
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and pays for
itself quickly
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● The NIAGARA AERO HEAT EXCHANGER transfers the heat from the quench bath to atmospheric air by evaporative cooling. It never fails to remove the heat at the rate of input, giving you real control of the quench bath temperature. This prevents flashing of oil quenches. In all cases it improves physical properties, saves loss of your product from rejections and gives you faster production, increasing your heat treating capacity. You

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New York 17, N. Y.

METAL PROGRESS, PAGE 136

Cracking of Soft Steel Under Stress and Corrosion

(Continued from p. 134)

micro-stresses, and also to the concentration of plastic distortion in such regions when the metal is plastically deformed. The extent of the distortion is sufficient to make the material anodic to the rest of the grain, so that the localized corrosion takes place; this will be very severe, because of the small area of the crack in comparison with the cathode area. The small pit, formed by the corrosion, concentrates the applied stress in the region of its base, and this stress increases the potential difference between the base of the pit and the cathodic grain interiors. If distorted by previous cold work or the presence of a nearby carbide particle, the distortion accompanying the stress concentration moves the potential to a sufficiently anodic value for further corrosion to take place. The crack may thus be propagated over the resistant region to the next region of distortion."

E. C. WRIGHT

Metallurgical Light on Aircraft Heater Failures*

SELECTION of materials, design, coatings, welding procedures and metallurgical considerations all are factors in determining the service life of aircraft combustion-type heaters. They are being investigated, both in the laboratory and in flying aircraft, by plane builders, materials suppliers and the manufacturer of this type of heater.

One study, for instance, is being conducted to ascertain whether a change in material from the presently used 309 Cr-Ni stainless steel will prolong life of the heater. A further purpose is to determine to what extent a ceramic coating will be beneficial and whether there may be coatings other than ceramic which have possibilities. Materials such as Inconel, Haynes No. 25 and other

(Continued on p. 138)

*Abstract of "Metallurgical Aspects of Aircraft Heaters", *Aircraft Heating Digest*, Vol. 3, No. 1, August 1952, published by Surface Combustion Corp.

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Thousands of metal working people are using the Crucible Tool Steel Selector to determine exactly which type of steel they need. This handy selector covers 22 tool steels which fit 98% of all tool steel applications.

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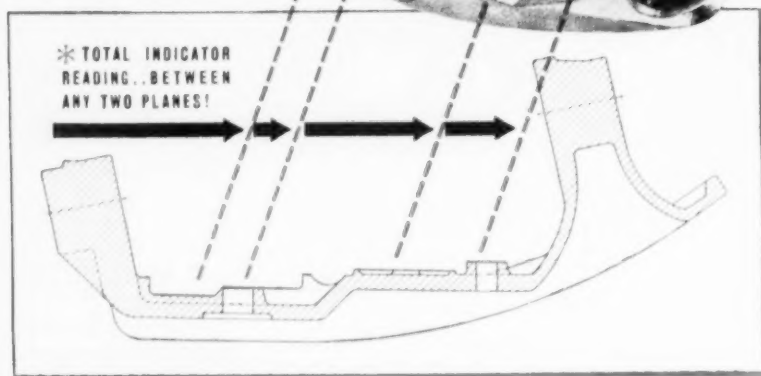
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DECEMBER 1953; PAGE 137

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Functioning as an important part of a mowing machine cutter mechanism, this Inner Shoe is responsible for holding all correlated parts in alignment. Accuracy must be maintained throughout the roughest service . . . and *initial accuracy* is a "must" in reducing assembly cost!

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Unitcast



QUALITY
STEEL
CASTINGS

Metallurgical Light on Aircraft Heater Failures

(Continued from p. 136)

analyses of stainless steels are being evaluated to find out whether they have desirable properties which could be profitably exploited.

In another metallographic test on a heater returned from service it was discovered that the sigma phase (a hard, brittle, intermetallic compound of Fe and Cr) was present in the grain boundaries of all sampled areas in the heat-affected zone. Degree of the sigma phase in the grain boundaries indicated that the metal was exposed to temperature above 1200° F. In Type 309 stainless, sigma phase will form readily at temperatures of 1100 to 1600° F., the amount and rate of formation depending upon time and temperature, and the level of internal stress in the steel.

Cyclic operation of the heater, or a differential rate of heating of its various parts, promotes high stresses and these may be of sufficient magnitude to cause surface cracks in the grain boundaries where sigma phase is present. During the time at operating temperature, severe oxidation will occur in grain-boundary cracks because of depletion of chromium from the area when the sigma phase was forming. Repeated heating and cooling cycles finally cause the crack to penetrate the metal shell.

In the test just referred to, no cracking had occurred in a weld and the failure was due to oxidation or burn-through. Samples of a bright orange contaminating material were scraped from the inner surface in two areas and X-ray diffraction analyses made. In one area, at the combustion zone, the chief compounds present were $PbSO_4 \cdot PbO$, $PbSO_4 \cdot 2PbO$ and Pb_2O . Slightly downstream from this area a darker material proved to be a mixture of Fe_2O_3 , NiO , $Cr_2O_3 \cdot NiO$ and $FeNi$. No bromine compounds were found in the latter area, suggesting that no reaction was taking place between the heat exchanger and bromine (from the gasoline) and that the temperature of the gases at this locality was high enough to prevent condensation of bromine compounds.

Presence of heavy lead sulphate and lead oxide deposits in the com-

(Continued on p. 140)

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METAL PROGRESS: PAGE 140

Metallurgical Light on Aircraft Heater Failures

(Continued from p. 138)

bustion zone and crossover ducts indicate a rapid and severe oxidation action had caused failure. Molten PbO in contact with stainless steel will continually flux off the protecting chromium oxide on the surface of the steel. While the melting point of pure PbO is 1630° F., this is reduced considerably when the oxide fuses with other metallic oxides. A high percentage of oxygen in flue products, plus lead oxide, makes for a severe corrosive condition on stainless steel.

Further research on a variety of specimens, including 19-9 stainless, Type 309 and 310, Inconel and Haynes No. 25 alloy, some coated with a Type A 418 enamel and others coated with pure aluminum, gave some conflicting results. They suggest the danger of regarding laboratory tests as conclusive and the necessity for depending finally on behavior of the material under exact field conditions.

It was found that the enamel coating was not impervious to attack of lead products, although it did inhibit to some degree the deterioration of the base metals involved. Aluminum coated panels were generally in better shape (after furnace exposure to flue products at 1500° F. for 100 hr.) than the enameled specimens. The No. 25 alloy panel, uncoated, withstood well the attack of flue products, yet in actual service the same material, enamel coated, outlasted the bare metal in the dry tube of a heater.

A. H. ALLEN

Steel Pipe Arc Welded Without Back-Up Rings*

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(Continued on p. 142)

*Digest of "Modern Practice in the Welding of Pipes—Background and Present Trends", by E. Fuchs and A. J. P. Tucker, *Transactions of the Institute of Welding*, Vol. 16, June 1953, p. 63-73.

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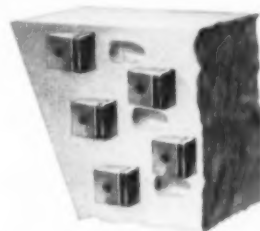
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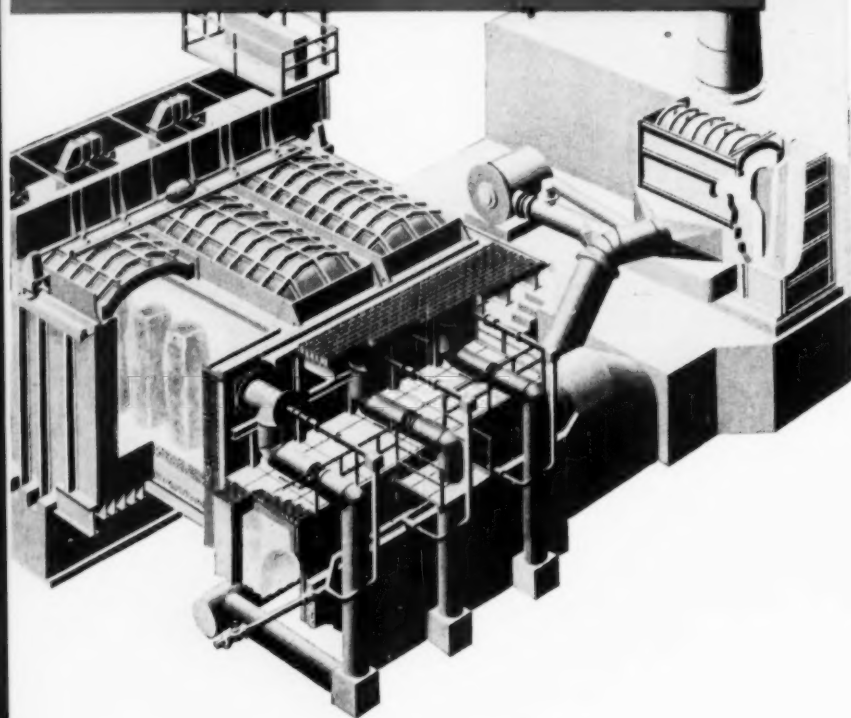
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Steel Pipe Arc Welded Without Back-Up Rings

(Continued from p. 140)

up rings. Such pipe is required widely throughout the British chemical industry, and the process is being examined with interest by the oil and steam power industries where welded pipe has conventionally made use of permanent steel backing rings.

Normal metal-arc welding did not give the high quality, homogeneous butt joint demanded, so special procedures were developed, involving five principal factors: (a) Use of a small-gage electrode for the root run; (b) close control of welding current; (c) a large root gap; (d) a root face; and (e) a weaving motion in laying the root bead, involving continuous movement of the electrode tip from side to side of the weld.

Welds have been made successfully in mild steel pipe with wall thicknesses of $\frac{1}{4}$, $\frac{3}{8}$, and 19/32 in., all with electrodes of 0.192 in. diameter for the root run. The direct current is held to 80 to 85 amp. for the two thinner gages, 85 to 90 amp. for the thicker. Too low a current results in incomplete penetration; too high results in collapse and burning through of the base metal at the point of welding.

A wide root gap is essential to allow the weaving motion of the electrode at the root. It varies from 1/16 to 1.9 in., depending upon wall thickness. The gap must be kept constant, since it tends to close on welding, so it is first tack welded after firm jiggling. On 4-in. diameter pipe, for example, $\frac{3}{4}$ -in. tack welds are used.

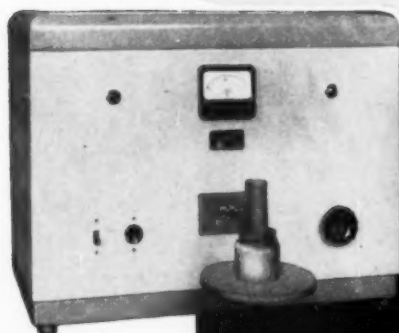
The joints are given a 30 to 35° chamfer and a relatively large root face. A minimum of 1/16 in. and ranging up to $\frac{1}{8}$ in. has been found satisfactory.

Most important feature of the welding operation is the manipulation of the electrode. A continuous arc must be maintained while the electrode is weaved from side to side of the root, with a slight pause at each side long enough to fuse the root face completely. The wide gap of the joint allows the welder to watch this process and to take cognizance of variations in depth of the root face. As the welding proceeds, a half moon is fused out at

(Continued on p. 144)

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Steel Pipe Arc Welded Without Back-Up Rings

(Continued from p. 142)

each side of the root just ahead of the deposited weld metal.

For rotated welds, the operator works upward from the 10 o'clock position, the deposited metal running slightly back from the electrode tip to permit observation of the degree of penetration. For positional welds in horizontal pipe, the work starts upward in each direction from the 6 o'clock position.

A typical time check on a 10-in. pipe showed a joint completed, with three runs of the electrode, in about 2½ hr., either rolled or positioned. A joint in a 4-in. pipe, also with three runs, was finished in 1 hr.

Control of weld quality is maintained by radiographic examination, periodic tests on welders and occasional removal and examination of completed welds. Careful training of welders is vital, for they must appreciate the need for holding a constant root gap and close control of current for the root bead. Inspection of fit-ups and close supervision of welding the root also have been found important.

Good results have been obtained with similar welding procedure on butt joints in austenitic Cr-Ni steel pipe of 3½-in. o.d. and 3/16-in. wall, as well as on smaller diameters. Tests have been made with three methods, one using shielding of the electrode with argon gas on all passes, a second using shielding only on the root run and the third no shielding. For the shielded arc passes, ⅝-in. diameter wire of 18-8-Ti steel was employed with direct current and the electrode connected negative. Current was 90 amp. for ⅝-in. wall, 140 amp. for 3/16-in. and ¼-in. wall. Joint preparation was similar to results obtained in mild steel pipe.

Bend tests on specimens cut from welds showed that both the metal-arc and the gas-shielded arc gave satisfactory results, control of penetration being easier and more uniform with the gas-shielded arc. Speed also was somewhat higher with the argon-protected arc, and weld cleanliness of a higher order. Advantages of gas shielding showed up even more in tests on welding 3% Cr-Mo steel pipe with 18-8-Ti filler wire.

A. H. ALLEN

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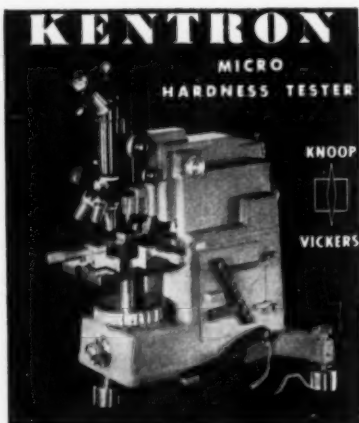
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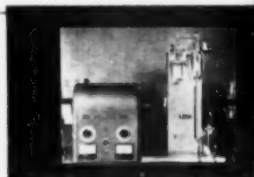
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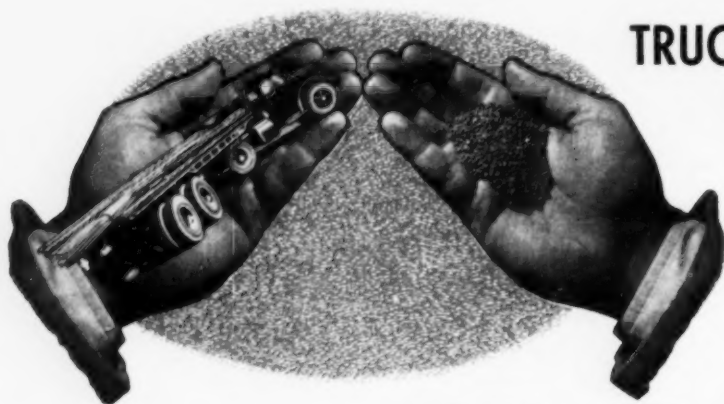
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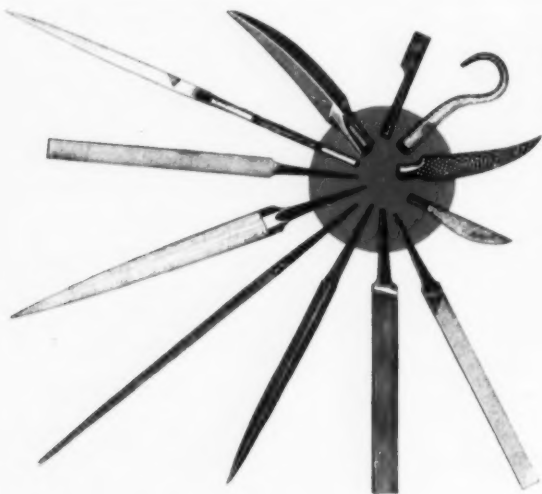


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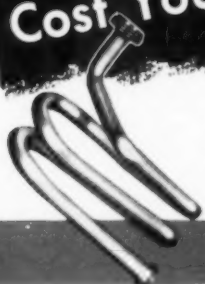
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METAL PROGRESS, PAGE 148

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3467 LOVETT AVE. DETROIT 10, MICH.

Phone TAshmao 5-0600

LIST NO. 40 ON INFO COUPON PAGE 158

Expand Your Plant Potential

WITH *Cooley* ELECTRIC HEAT TREATING FURNACES

fast . . . inexpensive way to expand your plant facilities. Choose from 27 Models.

For instance:

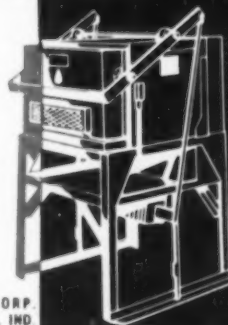


1. You save time and money by keeping heat treat jobs for small parts in plant.
2. It's easy to establish a new department at small cost in proportion to benefits which result.
3. Cooley heat treat furnaces pay for themselves through savings in time and subcontracting costs.
4. Heat treat operations are easily performed with Cooley designed furnaces.

Write now for Catalog giving complete details.

Cooley

ELECTRIC MANUFACTURING CORP.
38 SO. SHELBY ST. • INDIANAPOLIS, IND



LIST NO. 87 ON INFO COUPON PAGE 158

LET'S PUT OUR HEADS TOGETHER--- TO GET THE HEAT TREATING CONTAINERS YOU WANT!

Tell Stanwood Engineers your particular problem—type of parts you are heat treating—furnace capacity—cycle, etc. With our broad experience and production facilities we can supply baskets, trays, fixtures, carburizing boxes, retorts or furnace parts to exactly meet your needs—economically too! Send for literature.

Representatives in Principal Cities

Stanwood

4817 W. Cortland St.



Corporation

Chicago 39, Ill.



LIST NO. 12 ON INFO COUPON PAGE 158

Upton

... OFFERS
the most advanced
Salt Bath Furnaces

FOR ...

BATCH
TYPE
WORK

○

CONVEYORIZED
TYPE
WORK

○

ALUMINUM
BRAZING



UPTON ELECTRIC FURNACE CO.
16808 Hamilton Avenue
Detroit, Michigan
Phone: Diamond 1-2520

LIST NO. 20 ON INFO-COUPON PAGE 158

INDUSTRIAL FUEL BURNING EQUIPMENT..

Designed FOR YOUR SPECIFIC REQUIREMENTS

- Motor-Mix Burners
- Model DA Mixers
- Western Safety Valves
- Injector-Mix Burners
- Flame Retention Nozzles
- Accessories
- Inspirator-Mix Burners
- Blowers
- Multiport Burners
- Custom Built Equipment



Free descriptive literature on request

WESTERN PRODUCTS, Inc.

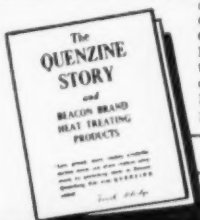
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New Castle, Ind. Chicago 6, Ill.

LIST NO. 93 ON INFO-COUPON PAGE 158

FREE

the QUENZINE STORY

Low priced, more readily available carbon steels can often replace alloy steels when quenched in Beacon Quenching Oils with QUENZINE added. For information on this new additive and other Beacon Brand Heat Treating Compounds write to ...



**ALDRIDGE
INDUSTRIAL OILS, Inc.**

3401 W. 140th St., Cleveland 11, Ohio

LIST NO. 29 ON INFO-COUPON PAGE 158

DEMPSEY FURNACES

GAS, OIL AND ELECTRIC
BATCH • CONTINUOUS

ATMOSPHERIC-RECIRCULATING-
PUSHER-ROTARY HEARTH-
CONVEYOR-RADIANT TUBE-POT
CAR-BOTTOM-ALUMINUM REVERBS.
"Tailored by Dempsey"



DEMPSEY INDUSTRIAL FURNACE CORP.
Springfield 1, Mass.

LIST NO. 79 ON INFO-COUPON PAGE 158

FAHRITE

HEAT AND CORROSION *Alloys*

Fahrte is used for:
 Rails • Trays •
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 Solution Pots •
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 Radiant Tubes •
 many other products

district offices



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TULSA, OKLAHOMA

THE OHIO STEEL FOUNDRY CO.

SPRINGFIELD, OHIO

Plants at Lima and Springfield, Ohio

ENGINEERS FOUNDERS FABRICATORS METALLURGISTS

LIST NO. 97 ON INFO-COUPON PAGE 158

METAL PROGRESS, PAGE 150

INDUCTION HEATING EQUIPMENT



Megacycle Tube Type Machines
Soldering • Brazing • Bombarding
Annealing • Hardening

Sizes: Standard—2,4,10,25 KVA; Custom—to 100 KVA

Fast • Powerful • Reliable

Challenge Comparison—Value • Quality • Price • Design • Appearance

Free Trial Run of Your Sample Parts

Complete data, application photos, prices, delivery in New illustrated Catalog. Write on your company letterhead.

Since 1930...Pioneers in Megacycle Heating



SHERMAN *Industrial Electronics Company*
 New York Area Office and Plant
 505 Washington Ave., Belleville 9, N. J.

LIST NO. 18 ON INFO COUPON PAGE 158

HEAT TREATING FURNACES

for
Every Heat Treating Process

★
CONTROLLED ATMOSPHERES

★
DIRECT FIRED

★
CIRC-AIR DRAW FURNACES

★
CIRC-AIR NICARB (CARBONITRIDING)

Specially Engineered for
Your Particular Needs

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GAS • OIL • ELECTRIC

INDUSTRIAL HEATING EQUIPMENT COMPANY
 3870 Fremont Pl. • Detroit 7, Mich.
Manufacturers of Industrial Furnaces Since 1917

LIST NO. 19 ON INFO COUPON PAGE 158

PULSATION-INSPIRATOR BURNER



Natural Gas at 1# to 30#

for KILNS • HEAT TREATING ANNEALING • DRAWING SLOW COOLING

OUR BURNER ELIMINATES COMBUSTION ATMOSPHERE STRATIFICATION BY CONSTANT AGITATION OF THE ATMOSPHERE. CATALYST LINER INITIATES CONTINUOUS IGNITION WITH MORE COMBUSTION IN SHORTER PERIOD THAN POSSIBLE THRU NORMAL DEFLAGRATION.

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 1413 W. TUSCARAWAS STREET
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LIST NO. 80 ON INFO COUPON PAGE 158

HEAT TREATING!

- ★ **Carburizing Salts**
 - ★ **Neutral Salts**
 - ★ **Tempering Salts**
- Faster more fluid baths!
 Free washing!
- Send for **FREE Literature TODAY!**

Swift
 INDUSTRIAL CANTON CHEMICAL COMPANY CONNECTICUT

SWIFT BLACK!

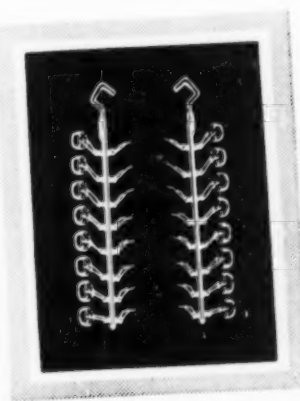
- ... for Blackening
- ★ Single or Double Bath Process to meet Any Requirement
 - ★ Faster, more Uniform Blackening
 - ★ Quality Control Formula gives Efficiency of Production
 - ★ Uniformity of Blackening Guarantees Economy

Send for **FREE Literature on Swift BLACK** and Cleaning Compounds **TODAY!**

Swift
 INDUSTRIAL CANTON CHEMICAL COMPANY CONNECTICUT

LIST NO. 92 ON INFO COUPON PAGE 158

Got a Problem? naraco HAS THE ANSWER!



With skill and ingenuity, NARACO engineers designed this fuse rack to answer the difficult problem of perfectly plating nozzles and ventricles. Need help? Call your NARACO office today.

NARACO

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 NATIONAL RACK CO. 179-181 Madison St. Paterson, N. J.
 IMPERIAL RACK CO. 1109 E. Stewart Ave. Flint, Michigan
 INDUSTRIAL RACK CO. 3462 San Fernando Rd. Los Angeles, Cal.

LIST NO. 14 ON INFO COUPON PAGE 158

20th
Century

the
persuasive
abrasive

Production curves take on a healthier look when you use 20th Century *Normalized shot, the persuasive abrasive. In daily use in foundries and metalworking plants everywhere, its high uniformity has proven it more efficient, more economical. Try it in your plant!

THE CLEVELAND **Metal Abrasive** CO.

836 East 67th Street, Cleveland 8, Ohio
Howell Works: Howell, Michigan

One of the world's largest producers of quality shot, grit and powder—Hard Iron—Malleable (*Normalized)—Cut Wire—Cast Steel (Realsteel)

*Copyrighted trade name

LIST NO. 2 ON INFO-COUPON PAGE 158



Portable
Agitators

Light weight, heavy duty models with swivel clamp. Available 1/4 to 3 HP sizes in three styles with either adjustable or rigid shafts. Ideal for Quench Tanks, Salt Baths, Plating Tanks and Waste Treatment.

CHEMINEER INC.

511 W. 2nd St., Dayton 2, Ohio

LIST NO. 102 ON INFO-COUPON PAGE 158

METAL PROGRESS, PAGE 152

today's
wonder drug
for industry

NOW...the greatest
cost-saving, labor-
saving. **FINISHING**
DEVELOPMENT in
a decade!

Make expensive time-consuming operations like filing, grinding, polishing, blasting, buffing a thing of the past with New Amazing SUPERSHEEN SPEED FINISHING.

It absolutely does away with costly hand deburring and other hand operations requiring the use of large quantities of expensive materials and costly skilled labor.

A single unit replaces from 2 to 12 men. Savings up to 95% on almost ALL types of parts with absolute uniformity, fewer rejects, finer finishes.

Investigate today!



Write for NEW
FREE, 62-page
Catalog

DEPT. J-7

ALMCO Supersheen

AMERICA'S LARGEST MANUFACTURER OF ADVANCED BARREL
FINISHING EQUIPMENT—MATERIALS AND COMPOUNDS
ALBERT LEA, MINNESOTA

LIST NO. 75 ON INFO-COUPON PAGE 158

Insist on

Since
1923

CIRCO

**METAL CLEANING
EQUIPMENT**

DEGREASING SOLVENTS

- VAPOR DEGREASERS
- METAL PARTS WASHERS
- STEAM CLEANERS

PER-SOLV (Perchloroethylene)
CIRCO-SOLV (Trichloroethylene)

Manufactured by
TOPPER EQUIPMENT COMPANY
Clark Township (Rahway) New Jersey

LIST NO. 10 ON INFO-COUPON PAGE 158

PYROSIL

Electric
Immersion
Heaters



for
METAL
PICKLING
& PLATING
SOLUTIONS

Totally inert to all acids at any concentration except hydrofluoric
Sizes: 1000 to 10,000 Watts

PYROSIL, Inc.
CUYAHOGA FALLS, OHIO

LIST NO. 106 ON INFO-COUPON PAGE 158

**DANIELS UTILITY
BATCH PLATER**



DANIELS PLATING BARREL & SUPPLY CO.

MANUFACTURERS and DISTRIBUTORS
Electroplating and Polishing Equipment and Supplies
129 Oliver Street, Newark 5, N.J. • Tel. Market 3-7450

New multiple DANIELS PLATING BARREL unit designed to handle small lots of work economically. Individual removable tanks allow plater wide range of plating, pickling, or cleaning applications.

Send for complete details on this and other plating equipment.



LIST NO. 17 ON INFO-COUPON PAGE 158

HOW TO DO BRIGHT GOLD PLATING

*without scratch
brushing or
buffing!*

GOLD
SILVER
RHODIUM

Write for complete details



BRIGHT GOLD PROCESS

**FOR INDUSTRIAL and
DECORATIVE USES**

1. Exceptionally hard deposits — twice the hardness of conventional gold plating.
2. Operates at room temperature — requires absolute minimum control.
3. Excellent metal distribution and "throwing power."

SEL-REX PRECIOUS METALS, INC.

Dept. 88, 229 Main Street
Belleville 9, N. J.

LIST NO. 108 ON INFO COUPON PAGE 158

WELDCO

FABRICATED MONEL PICKLING EQUIPMENT

• Hairpin Hooks • Sheet Crates

• Steam Jets • Chain

• Mechanical Bar, Tube and Coil Picklers

THE YOUNGSTOWN WELDING & ENGINEERING CO.

3728 OAKWOOD AVENUE • YOUNGSTOWN 9, OHIO

LIST NO. 94 ON INFO COUPON PAGE 158

BASKETS

for all
industrial
requirements

for de-greasing — pickling
anodizing — plating
materials handling
small-parts storage

of any size and shape —
any ductile metal
by

THE C. O.

JELLIFF

MFG. CORP.
28 Pequot Road
Southport, Conn.



LIST NO. 91 ON INFO COUPON PAGE 158

Du-Lite

**"Gives our tools
Sales Appeal"**



BARNABY MFG. CO. of Bridgeport, Conn., reports: "Our close proximity to salt water has given us problems in rust prevention for many years. We have experimented with many black oxide finishes but none has proven as successful, safe, and inexpensive as DU-LITE—our tools have better sales appeal—our volume has been on the increase ever since we started using this modern, progressive oxide finish."

Depend on Du-Lite, the metal-finishing specialists, for the most efficient and economical cleaners, black oxide finishes and phosphate coatings. Write for full details on:

Du-Lite Black Oxide for Steel.

3-0 Black Oxide for stainless steel and malleable iron.

SD Compound for removing occluded salts. Phossteel and Phospray for phosphatizing steel, iron or zinc.

Du-Lite Non-Acid Black Oxide for copper and copper alloys.

Dynakleen for bright cleaning all metals.

Kwikseal and Proctail water displacing oils.

Or send us samples of parts and we will process them for your approval.

DU-LITE CHEMICAL CORP.

MIDDLETOWN, CONN.

- Send more information on Du-Lite..... ☐
Send information on metal finishing products... ☐
Have your representative call..... ☐

Name.....
Company.....
Address.....
City..... Zone..... State.....

Du-Lite

METAL FINISHING SPECIALISTS

LIST NO. 103 ON INFO COUPON PAGE 158

METAL PROGRESS; PAGE 153

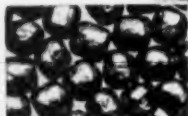
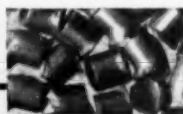
You can cut Cleaning and Peening costs

66%
with
Park
Cut Wire Shot

Shatter-proof Park Cut Wire Shot is made of hardened clipped carbon steel wire. It will outperform and outlast breakable cast shot. That is why you can save up to 66% in cleaning and peening costs.

- 1. Durability**
Tests prove Park shot lasts from 8 to 10 times longer.
- 2. Storage — Shipping**
One bag of Park shot does the work of 8 bags of cast iron shot.
- 3. Maintenance — Wear**
Sharply reduced maintenance costs and wear on equipment.
- 4. Material Costs**
Definite savings on steel costs when peening with Park shot.

New Cut Wire
as added to
machine.



After 14 1/2
hours.

After 68 days.



Write for bulletin and prices.

PARK CHEMICAL COMPANY
8074 Millbury Ave., Detroit 4, Michigan

LIST NO. 34 ON INFO COUPON PAGE 158

METAL PROGRESS; PAGE 154



MANHATTAN

Abrasive Wheels — Cut-off Wheels
Finishing Wheels—Diamond Wheels

Custom-made for your specific
material removal problems

**Foundry Snagging—Billet
Surfacing—Centerless Grinding**

Cutting and Surfacing concrete,
granite, and marble

"Moldiscs" for rotary sanders

Grinding and Finishing
stainless steel welds

**Bearing Race Grinding
and Finishing**

Finishing Tools and Cutlery

**Cutting-off—Wet or Dry Bars, Tub-
ing, Structural, etc. Foundry Cutting**
—standard and reinforced wheels

Grinding Carbide Tipped Tools

Write to Abrasive Wheel Department
Raybestos-Manhattan, Inc.
MANHATTAN RUBBER DIVISION
92 TOWNSEND ST. • PASSAIC N. J.

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- Economical
- No Change in Dimension
- Corrosion Resistant
- Perfect Uniformity
- Non-Technical

**The Black Oxide Finish That
Penetrates Iron & Steel Surfaces**

PURITAN MANUFACTURING CO.
WATERBURY, CONN.

LIST NO. 95 ON INFO COUPON PAGE 158

HERE'S HELP for your engineer- recruitment problem

*Engineers' Joint Council
and The Advertising Council
offer free, expert help to
advertisers promoting engi-
neering as a career.*

A booklet has been prepared by The Advertising Council in cooperation with the Engineers' Joint Council to help you in recruiting engineers for the future.

1. It tells you what the problem is and the important part you can play in solving it.
2. It outlines the advantages of an engineering career to help your company develop advertising appeals.
3. It informs you as to the current activities of industry in the education and recruitment of engineers.
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Many companies are using this booklet today. They say that it helps in orienting their engineer-recruitment advertising to industry-wide recruitment programs. Send for the booklet now. Address: The Advertising Council, Inc., 25 West 45th St., New York 36, N.Y.

*This space contributed by
American Society for Metals*

ARDCOR*Engineered***TUBING ROLLS
AND
FORMING ROLLS**

To Your Specifications or Ardcor Design—for all makes of machines.

Also, manufacturers of Straightening, Pinch and Leveller Rolls.

ARDCOR ROLLER DIES • ROLL FORMING MACHINERY • CUT-OFF MACHINES

American ROLLER DIE CORPORATION

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Wickliffe, Ohio

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**A CABLE SPliced
IN 10 SECONDS!****ERICO PRODUCTS, INC.**

Complete Arc Welding Accessories

2070 E. 61st Place, Cleveland 3, Ohio

Write for Caddy Catalog

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**RESIDUAL STRESS
MEASUREMENTS**

This volume, written by four outstanding authorities, devotes 204 pages to the important problem of the nature and extent of residual or "internal" stresses in metals and metal parts prior to actual structural or operating use.

How to measure residual stresses . . . The state of stresses produced in metals by various processes . . . Relief and redistribution of residual stresses in metals . . . How residual stresses originate, their nature and their effect on metals.

204 pages, \$4.50

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INDUSTRY'S MOST
VERSATILE LUBRICANT

The tremendous lubricity of MOLYKOTE depends on the unique molecular structure of the compound. Read the story behind its development and the jobs it can do better than any other lubricants.

Send for free catalog today!

THE ALPHA CORPORATION
Greenwich, Conn.

LIST NO. 110 ON INFO-COUPON PAGE 158

**MAURATH
INC.**

MANUFACTURERS • PROCESSORS
OF STAINLESS
AND HEAT RESISTANT
ARC WELDING
ELECTRODES

**AUTOMATIC WELDING**

ALL ANALYSES—COATED,
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CUT, OR COILED

Telephone:
Montrose 2-6100

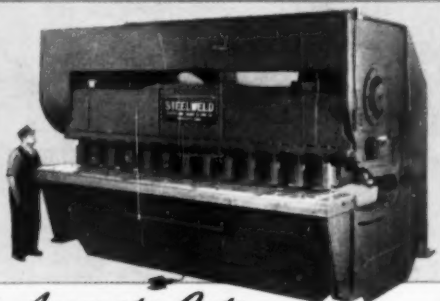


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STEELWELD PIVOTED BLADE SHEARS

Radically Different

Steelweld metal-cutting shears are entirely new with advantages never before possible. Revolutionary pivoted-blade travels in circular path and overcomes handicaps of ordinary guillotine-type shears. No slides or guides to wear and cause inaccuracies. Many other important features. Complete line machines for shearing metal up to 20 feet long or in thicknesses to 1-1/4 inch.



Straight Accurate Cuts

Not only are these machines easier to operate but their design assures smooth straight cuts to hair-line accuracy for years of operation. Their construction is extra heavy, and all modern features are incorporated to provide for ease of operation, minimum maintenance and long life.

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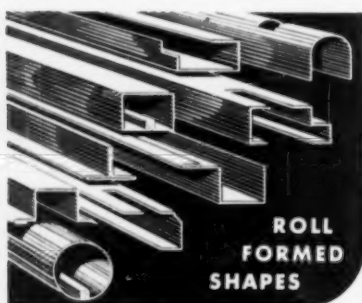
FEATURES GALORE

1. All-welded solid one-piece frame.
2. Electric foot control.
3. Fast Micro-Set Knife Adjustment.
4. Deep throat for wide slitting.
5. Lift-up Back Gauge.

THE CLEVELAND CRANE & ENGINEERING CO.

3939 East 282nd Street • Wickliffe, Ohio

LIST NO. 59 ON INFO-COUPON PAGE 158



ROLL FORMED SHAPES

Reduce your assembly problems and costs. Our shapes continuously formed, with high degree of accuracy, from ferrous or non-ferrous metals. Write for Catalog No. 1053.

ROLL FORMED PRODUCTS CO.

MAIN OFFICE AND PLANT
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LIST NO. 101 ON INFO-COUPON PAGE 158

RUST-LICK IN AQUEOUS SYSTEMS

For HYDROSTATIC TESTING

Eliminates . . .
Rust
Fire Hazards
Toxicity
Dermatitis
Washing

WRITE FOR FREE SAMPLE & BROCHURE

PRODUCTION SPECIALTIES, INC.
755 BOYLSTON STREET
BOSTON 16, MASS.

LIST NO. 105 ON INFO-COUPON PAGE 158

Cut Costs With FREE Cutting Oil Chart

Use this free cutting oil chart as a handy guide to production costs and to more efficient machining operations.

Steel and nonferrous metals are charted with the proper cutting oil for many applications. Shows you how to use lubricants, sulphurized or compounded with extreme pressure additives, for all operations.

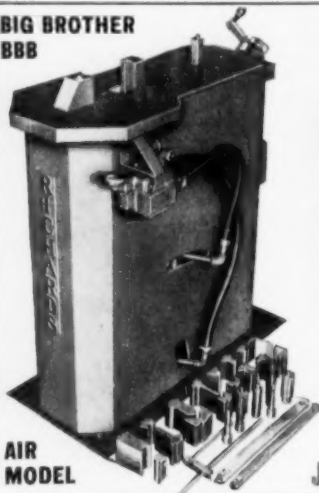


ALDRIDGE INDUSTRIAL OILS, Inc.

3401 W. 140th St., Cleveland 11, Ohio

LIST NO. 100 ON INFO-COUPON PAGE 158

BIG BROTHER BBB



AIR MODEL

Multiform



Illustrated above are a few of the many forms that can be produced efficiently on the Multiform Bender, using the standard tooling.

WRITE TODAY FOR FULL INFORMATION

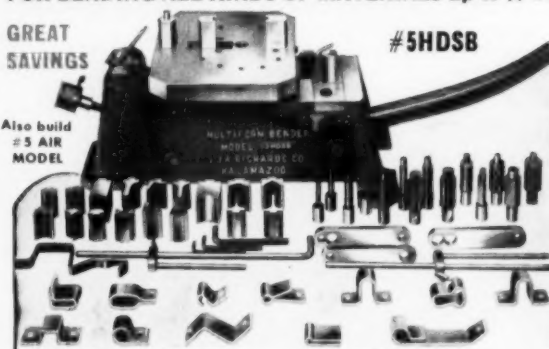
BENDERS-CUTTERS 20 MODELS

FOR BENDING ALL KINDS OF MATERIALS up to 1/4" x 14"

GREAT SAVINGS

#5HDSB

Also build #5 AIR MODEL



J. A. RICHARDS CO. • 913 N. Pitcher St. • Kalamazoo, Michigan

LIST NO. 107 ON INFO-COUPON PAGE 158

METAL PROGRESS; PAGE 156

*Increased
Production
Longer Die Life
Less Scrap*

These are claims of users of
HANGSTERFER'S LUBRICANTS
who are Drawing, Drilling,
Reaming or Tapping stainless
steel or other hard metals.

HANGSTERFER'S LUBRICANTS
are doing the job for major
metal working plants here
in the United States and
in Europe.

**HANGSTERFER'S
LABORATORIES**
21 COOPER STREET
WOODBURY, NEW JERSEY

LIST NO. 85 ON INFO-COUPON PAGE 158

WHITELIGHT MAGNESIUM

your comprehensive independent
source of magnesium alloy
Tubes • Rods • Shapes • Bars
Hollow Extrusions • Plate • Sheet
• Pipe • Wire • Welded and
Riveted structures and assemblies



**WHITE METAL ROLLING
& STAMPING CORP.**

82 Moultrie St., Brooklyn 22, N. Y.

Sales Office
376 Lafayette St., New York 3, N. Y.

LIST NO. 67 ON INFO-COUPON PAGE 158

Use Atlantic Fluxes

ALUCO ...

For degasifying and purifying
aluminum alloys. Assures uni-
formly sound, dense grained
castings. Used in reverberato-
ry and crucible-type furnaces.

ALUCO 'S' ...

Specially compounded for die
casting aluminum-base metal
and permanent mold castings.

MAGNESAL ...

Used for removing magnesium
from aluminum alloys.

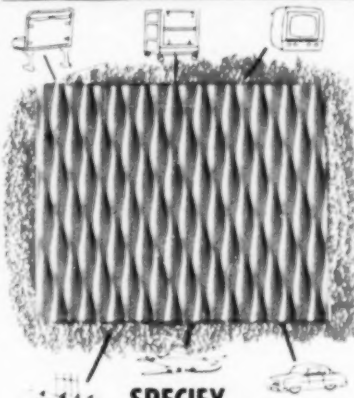
ALUCO 'GR' & 'DG' ...

For grain refining and degasi-
fying aluminum and its alloys.

Atlantic Chemicals & Metals Co.
1921-27 NORTH KENMORE AVE.
CHICAGO 14, ILLINOIS, U.S.A.

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**STRENGTHEN
BEAUTIFY
PROTECT
your product**



SPECIFY

RIGID-tex METALS

Take that new product of yours, make
it dent-scurf-scratch-resistant, give it
plenty of rugged impact resistance,
reduce its weight and double its
strength, and finish it up by packing
it full of buying-eye appeal. You can
do all this when you specify Rigid-
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designs! Find out for yourself.

Write on your company letterhead.



**RIGIDIZED METALS
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U. S. & Foreign Patents

35 Wholesome and Johns Roads
All Principal Cities Through-
out the U. S. and Canada

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**Solve
EXTREME
PRESSURE
LUBRICATION
with**



The new miracle—multi-purpose
molybdenum disulfide lubricant.

Anti-Seize is a stable non-melting
lubricant having a phenomenal
capacity to prevent seizing and
galling at bearing pressures well
over 100,000 pounds per square
inch. Anti-Seize will lubricate at
temperatures below sub-zero
and up to 750 degrees F.

Write today
DEPT MP
for new literature
and get the
complete story

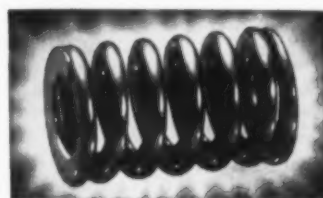


MANUFACTURERS OF THE MOST COMPLETE LINE
OF MOLYBDENUM DISULFIDE LUBRICANTS

BEL-RAY CO., INC.
MADISON, NEW JERSEY



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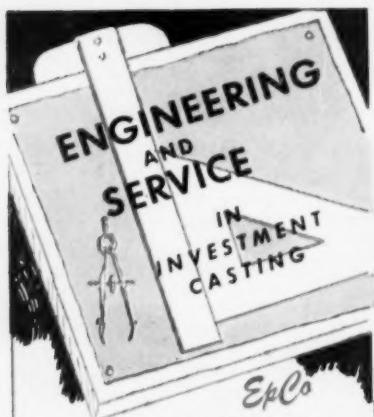
**COMPRESSION • TORSION •
FLAT • EXTENSION • AND
SPECIAL TYPE SPRINGS**



**METAL STAMPINGS AND
WIRE FORMS**

JOHN EVANS' SONS, Inc.
1316 & NECTARINE STREETS
PHILADELPHIA 21, PENNA.

LIST NO. 45 ON INFO-COUPON PAGE 158



**A PROVEN
DEPENDABLE SOURCE
FOR BETTER GRADE INVESTMENT
CASTINGS IN FERROUS AND
NON-FERROUS METALS**



**INVAR
CASTING**
Special Feature
— Nickel content
held to 35% min-
imum — 36%
maximum

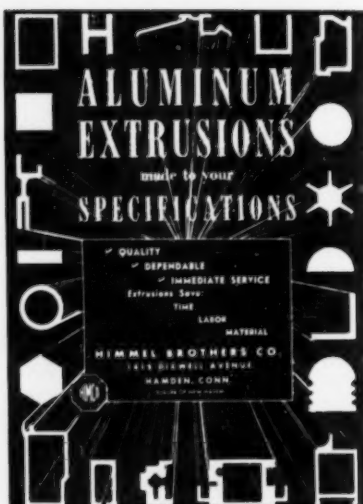
STAINLESS STEEL PART for milk
bottling unit formerly machined
from solid stock.
Only finish oper-
ations required
are reaming small
dia. of counter-
bored hole and
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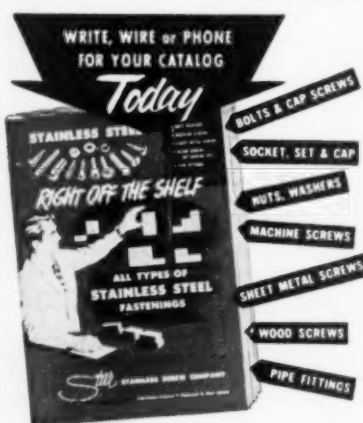
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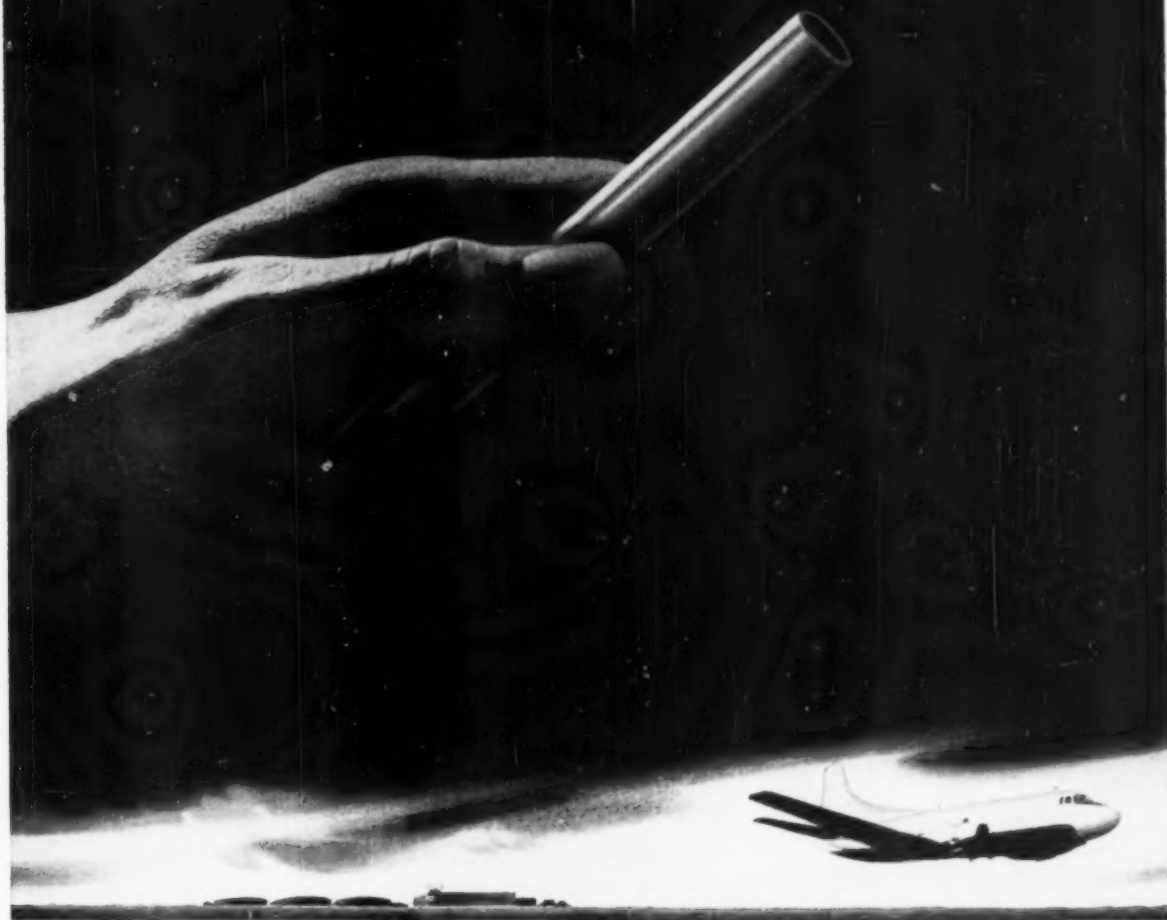
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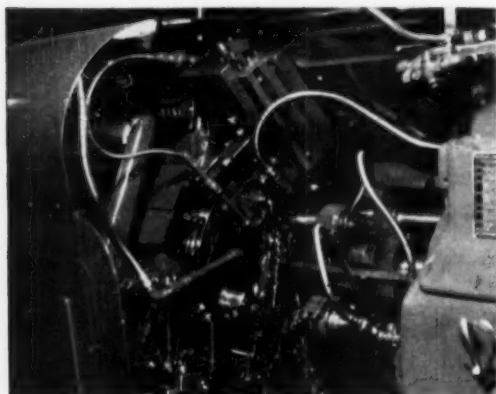
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By SAM McCaULLEY, Silver Division
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portion to flow away from the solid when the alloy is in the mushy state, and it is, therefore, advisable to limit the time these alloys are held in the melting range. Melting and flow temperatures are published by most manufacturers as an indication of melting behavior.

Clean metal surfaces are required for brazing, and care in proper preparation of the parts will pay dividends in results. Fluxes are used to maintain the prepared surfaces through the heating cycle. They perform three functions:

1. By covering the work during heating and brazing they prevent oxidation of the surfaces

Some Practical Pointers on Silver Alloy Brazing

SILVER is a high-priced material and it is not used in brazing alloys because of personal preference or its appearance. It is used because alloys containing silver produce the desired joint most economically. When you buy silver brazing alloys, you are paying for brazing properties—you are buying strong, ductile alloys with low melting temperatures and free flow. These alloys will braze joints at the lowest possible temperatures, they will simplify the joining operation, and they lend themselves to mechanization of the brazing process. The brazing alloy that will give the lowest over-all cost of the joint is usually the alloy with the best flowing properties and lowest brazing temperatures.

About 20 compositions are considered standard today. Many are intended only for specialized applications; a relatively few of the lowest-temperature alloys serve most industrial uses.

These alloys may be divided into two types. One type passes in melting from a solid to a liquid within a few degrees of temperature; the other type passes from a solid to a mushy stage, and progressively becomes more liquid until melting is completed. The first type is generally preferred for brazing of close-fitting joints. The second type is sometimes advantageous if joint fit-ups are poor or inconsistent. With the second type, there may be a tendency for the liquid

2. They may dissolve, reduce or float off surface oxides and tarnish.

3. They reduce the surface tension of the alloy, causing it to flow more freely over the work surfaces and into the joint.

Fluxes consist of combinations of borates and fluorides in a water paste. Fluorine is the active ingredient in all silver brazing fluxes. It is a toxic element and care must be taken to avoid bodily contact with flux or its fumes. The corrosive residue is removed by washing in water.

Figure 1 shows basic joint designs for silver brazing. The lap joint at the top is preferred for most applications. The area of the joint can be increased as desired by increasing the lap, and the parts are readily positioned. Butt and scarf joints are used where space is limited. Preparation and positioning of these joints is difficult and joint area is limited.

In practice, joint designs are more complex, and frequently a combination of butt and lap designs is used. For example, in silver brazing the hub and shaft assembly shown in Fig. 2, there are several possibilities. First, the shaft might simply be butted against the hub, but the limited area of the joint makes this design objectionable. The straight shear joint is preferred but the design can be further improved, as shown at the right of Fig. 2, by a combination

Strong Silver Brazed Joints

of butt and lap, giving more joint area in critically stressed areas. A further improvement can be made by modifying the hub for better distribution of stress in this area.

Proper clearance must be provided between members for proper filling of the joint. This runs from 0.001 to about 0.008 in., with the ideal dimension probably about 0.003 in. A clearance of at least 0.001 in. is necessary for the molten alloy to enter the joint and displace flux and gas inclusions. Above 0.006 or 0.008 in. the alloy will not be held within the joint by capillary attraction.

These clearances must be held at the temperature at which the brazing alloys flow. If the parts of an assembly such as the hub and shaft are of the same metal — steel, for example — the calculation of clearances is elementary. If they are of dissimilar metals, the determination of clearances must take into account the difference in thermal expansion of the parts. For example, if the hub is steel and the shaft is brass, an allowance of 0.010 in. on a 2-in. diameter must be made for the greater expansion of the brass. The coefficient of thermal expansion may be determined from a reference book such as

Fig. 1 — Basic Joint Designs for Silver Brazing. Use of preforms such as washers, rings or other shapes in various positions is an aid to mechanization of the process.

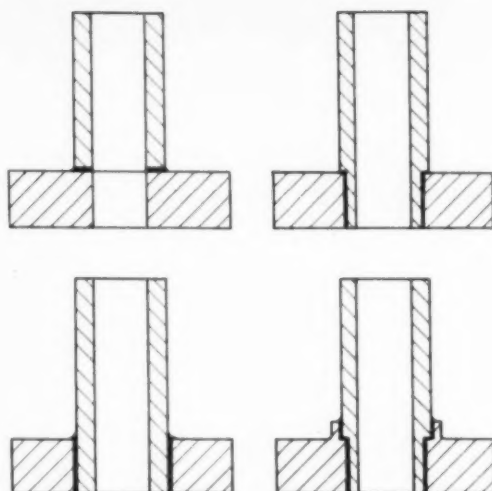
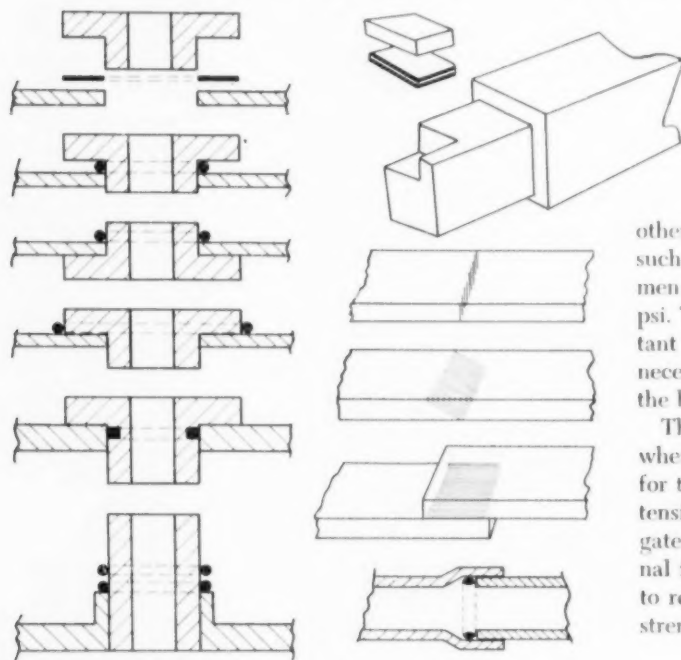


Fig. 2 — Four Types of Joints for a Brazed Hub and Shaft Assembly

"Metals Handbook", 1948 Edition. The normal clearance of 0.003 in. must be provided in addition to this 0.010-in. clearance for thermal expansion.

One of the first questions asked by the layman about silver brazing is "How strong is the joint?" This is a difficult question to answer. For example, a tensile specimen made of copper with a brazed joint will stand about 30,000 psi. ultimate load. This approaches the strength of copper itself; nevertheless, the failure does occur at the joint boundary or immediately adjacent

to it. If the test were repeated with a specimen of silver alloy, we would find that it failed at about 60,000 psi. This figure represents the ultimate tensile strength of almost all of the silver brazing alloys, although some are slightly stronger than

others. With a stronger, harder metal, such as stainless steel, the same specimen would withstand perhaps 120,000 psi. Thus, the base metal has an important influence, and joint strength is not necessarily limited by the strength of the brazing alloy.

The behavior of a tensile specimen when deformed may explain the reason for this to some extent. Under load the tensile specimen becomes slightly elongated and somewhat narrower. If external forces are placed on this specimen to restrain its deformation, its ultimate strength will be affected. This is essen-

(Continued on p. 164)

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tially what happens to the silver alloy in a brazed joint. The rigidity of the base metal prevents the thin layer of brazing alloy from deforming according to its natural characteristics, and this, in effect, increases its load-carrying ability. Conversely, with a softer, weaker metal, deformation will result in lower strength at the joint.

The advantage of small joint clearance for high strength is therefore readily appreciated; the base metal is able to exert its influence on the joint only if the alloy layer is thin.

For best strength characteristics, stress concentrations should be avoided in parts design; service tests on sample assemblies will provide helpful design data. In the widely diversified applications of silver brazing all methods of heating may be used. Whatever the heating process, the main requirement is to bring the two members of the joint quickly, evenly and simultaneously to the brazing temperature. This demands considerable skill in torch brazing, since the operator must know the heat requirements of various metals and be able to estimate temperature during heating.

The use of preformed rings or other forms preplaced about the joint is recommended wherever feasible, and has permitted mechanization of many brazing operations. Even in manual torch brazing, the use of a preform eliminates one of the human-element factors.

Wherever possible, the alloy should be placed so that it will flow actively into the joint so as to give better alloying with the surface and reduce the chance for flux and gas inclusions. If the alloy can be fed from one edge through to the opposite edge of the joint, the operator will have some indication of how the joint is being filled with alloy. It may also be possible to locate the alloy within the joint so that it will flow out until visible at the boundaries. Such a practice is often used to join electrical busbars.

The final joint should have smooth, natural fillets. Fillets which are built up after the fashion of a weld may be useful in some applications, but again may be merely a veneer over an empty joint. When developing a new procedure, sample parts should be cut open and the joint inspected; the process can then be altered to obtain best results.

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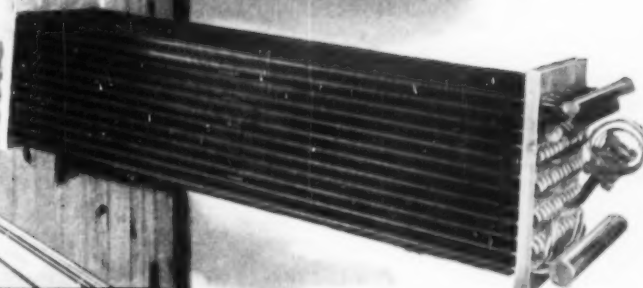
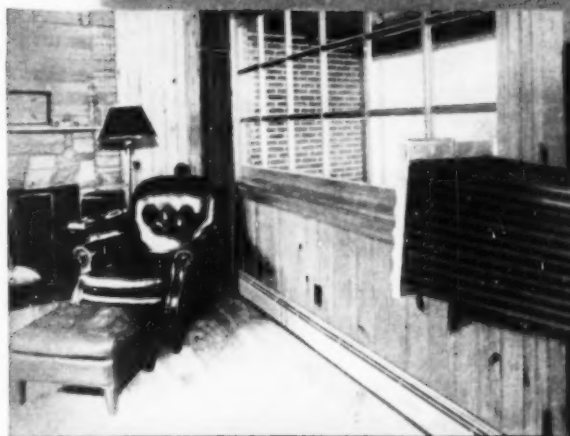
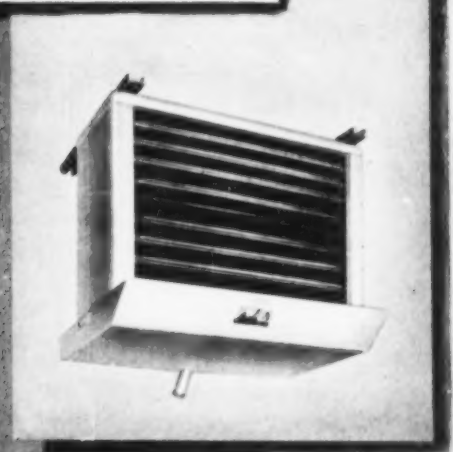
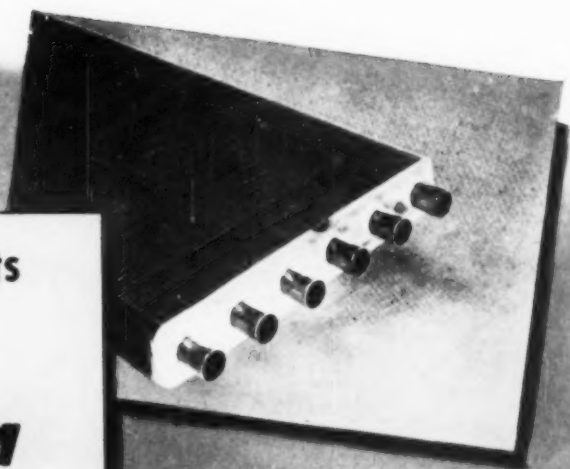
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The British Cast Iron Research Association studied the effect of nitrogen upon a series of cast irons of different types. These included both hypo-eutectic and hypereutectic gray irons, a white cast iron which was deemed appropriate for the manufacture of malleable castings—although by American standards it was much lower in silicon (about 0.50%) and much higher in carbon (over 3%)—and nodular cast iron.

Their irons were made in oil-fired furnaces, the nitrogen additions being found to be best made from sodium ferrocyanide plus an equal amount of anhydrous sodium carbonate. Calcium cyanamide plus an equal weight of sodium carbonate could also be used, as well as sodium ferrocyanide alone. Calcium cyanamide, without the fluxing addition, was not so efficient. Additions of 2½ oz. of sodium ferrocyanide plus an equal weight of sodium carbonate to 45 lb. of metal, produced a nitrogen content of 170 parts per million.

When rather considerable amounts of ferrocyanide are used, the molten iron can dissolve sufficient nitrogen to cause gas evolution and blowholes on cooling. This occurred in the region of 335 parts per million.

The effect of nitrogen additions on all the cast irons seems to be the stabilization of the iron carbides. With the hypo-eutectoid cast irons, represented by two melts, the best properties occurred at about 200 or 225 parts per million of nitrogen. The chill of hypo-eutectoid gray iron increases markedly with increasing nitrogen content. With the hypereutectoid, the best properties occurred at 175 parts per million.

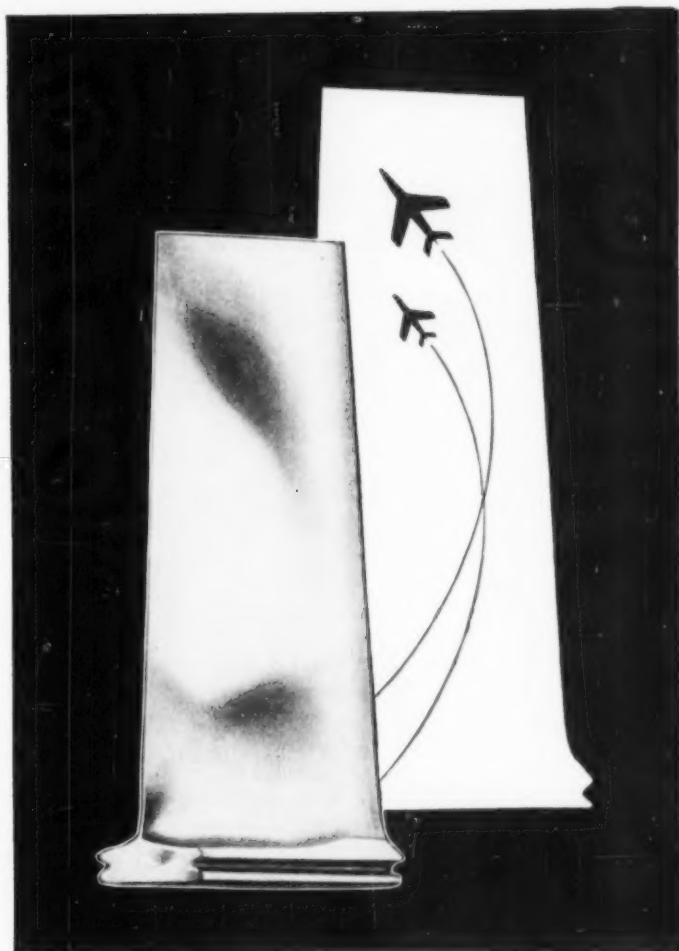
During remelting, cast irons lose much of the nitrogen obtained from ferrocyanide, but, as might be expected—

(Continued on p. 170)

*Digest of "Some Effects of Nitrogen in Cast Iron", by J. V. Dawson, L. W. L. Smith and B. B. Bach, *Journal of Research and Development of the British Cast Iron Research Association*, Vol. 4, June 1953, p. 540-552.



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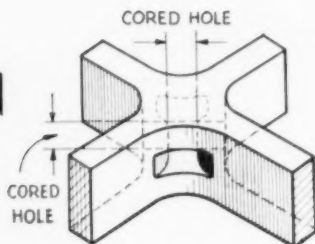
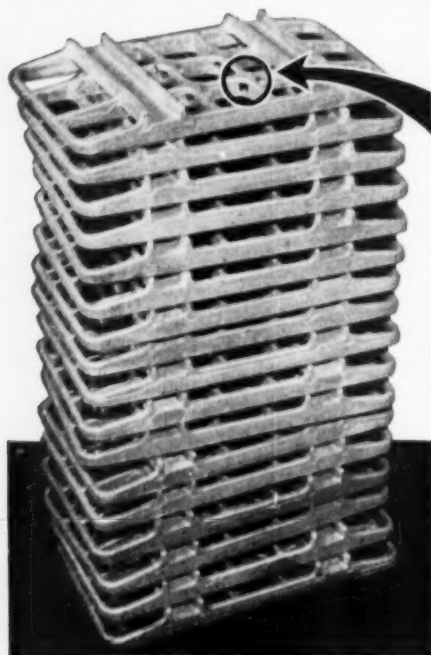
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Grid intersections are cored horizontally and diagonally through the neutral axis. Metal thus removed from regions of low stress is added to areas of high stress, where it increases load capacity, reduces distortion, and gives much longer life. U.S. PAT. 2242554.

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Nitrogen in Cast Iron

(Continued from p. 168)

pected, can be again nitrified by the fluxing treatment.

The graphitizing rate of the single heat made to simulate malleable practice was quite markedly decreased with increasing nitrogen content. This was true both of the destruction of massive carbides and of the destruction of pearlite. Fast heating in the graphitizing cycle produced relatively few nodules but all of which were large. On slow heating, as was expected, the number of nodules increased, as did the graphitizing rate. However, nodules of large size persisted with the higher nitrogen contents.

Three melts were made to which aluminum was added to counteract the effect of nitrogen. The effects did not seem to have been very consistent but did indicate a favorable effect on the part of the aluminum. The only important effect of the nitrogen on nodular cast irons seems to be the retention of somewhat more pearlite. It is reported that commercial cast irons show nitrogen to range from 20 to 150 parts per million.

In the words of the authors, "The results obtained confirm the carbide stabilizing effect of nitrogen already noted in carbon steels. The effect of aluminum in neutralizing the effects of nitrogen has also been confirmed. The effect of nitrogen on embrittlement, if any, has not yet been investigated. In the case of nodular cast iron, the only increase in strength due to the presence of nitrogen is that which arises from an increase in amount of pearlite in the as-cast condition." H. A. SCHWARTZ

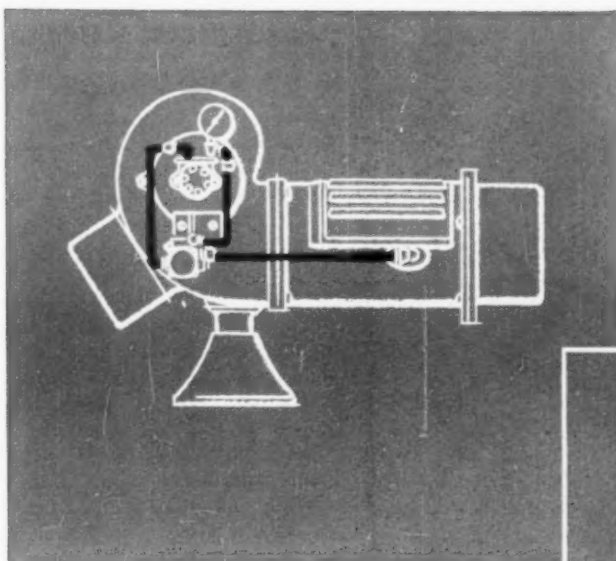
Fundamental Research

(Continued from p. 100)

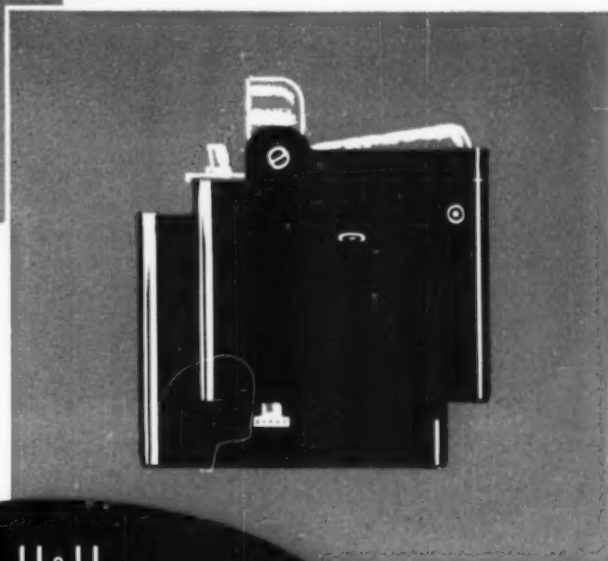
increased scientific attention to the general fields of electrode kinetics and of metal surfaces.

"As an illustration of the first field—electrode kinetics—we are in dire need of accurate anodic and cathodic polarization data for all metals and alloys in a variety of environments. Through such information, we can attain a better understanding of galvanic coupling, incidence of pitting, why metals are passive in some en-

(Continued on p. 172)



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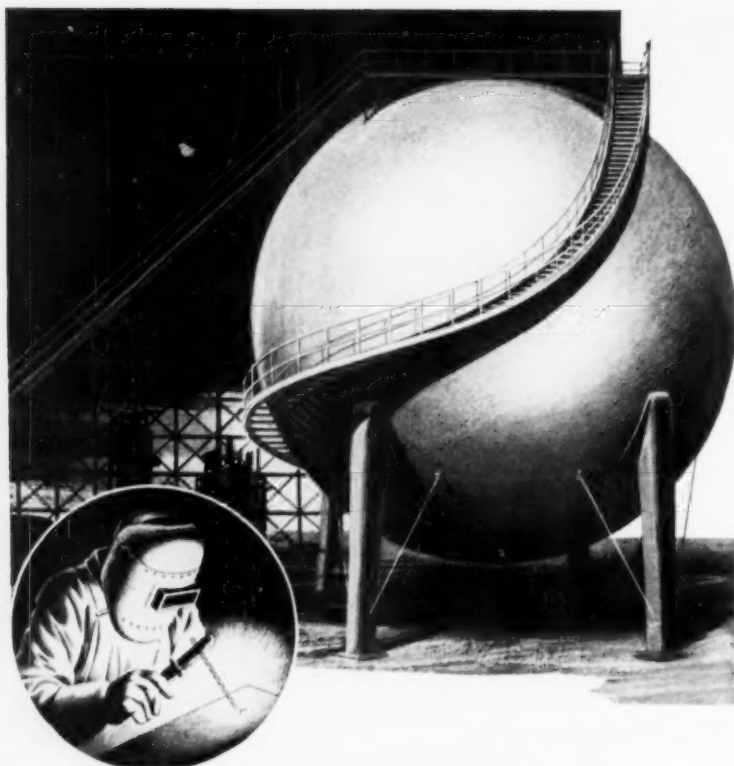
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You can profit from this same advantage by using Arcos Low Hydrogen Electrodes for welding high tensile steels. With few exceptions, once you select the proper electrode, you can keep on welding with *one electrode*—no need to change electrodes for different welding positions. Besides saving time, inventory can be simplified.

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ARCOS CORPORATION, 1500 South 50th Street, Philadelphia 43, Penna.



WELD WITH
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LOW HYDROGEN ELECTRODES

Fundamental Research

(Starts on p. 100)

vironments and not in others, and the factors that influence corrosion rates. Precise cathodic data are now available for very few metals—perhaps only platinum and mercury. Similarly, there is a discouraging paucity of precise anodic data. Information of this kind, even though now missing for aqueous solutions, must eventually also include fused salts and organic electrolytes at various temperatures and pressures, and under conditions of low and high velocities.

"As an illustration of the second field—fundamental studies of metal surfaces—information is needed on the effect of lattice imperfections on the nature of chemical attack and its rate as affected by the environment, on rates of adsorption of gases, and initial reaction rates resulting in reaction-product films. Data in this category are essential to our understanding of stress-corrosion cracking, corrosion fatigue and fretting corrosion. We should, furthermore, know more about the relations between types of bonding and electron configuration in metal systems to adsorbed films, reaction-product layers and kinetics of metal reaction generally. Surface studies should include the nature of bonding between metal and films of reaction product, and the detailed structure of the metal-non-metal interface. Our understanding would thereby be improved of passivity and of factors affecting spalling of protecting layers, as well as of the variables entering the adherence of paints to phosphate coated metals.


"This list is far from complete, and the fundamental problems that bear on corrosion reactions are much broader than is implied by the two fields named above. Nevertheless, I believe that any systematic attempt to focus greater scientific attention on these fields would inevitably result in impressive advances of far-reaching importance to those concerned with corrosion problems—which means practically everybody."

Obviously these are not simple problems. The time required for their full solution cannot be encompassed in a five-year plan. The number of researchers who have the required scientific perspective is small when viewed against the background of these two extensive fields of study.

An obvious corollary is that we need more research workers who are competent in both physical chemistry and metallurgy.

In addition there is a third type of problem which one might classify as a problem in industrial management or national conservation or, if you like, a problem in planning. The Editor has already stated this problem but it bears repeating. Simply this:

Our ignorance is costing us billions per year. Our efforts to combat corrosion in our present partially blindfolded state are costing us millions. Our actual fundamental research on underlying problems is costing us thousands.

How can these figures be brought more nearly into balance? How can our present centers of research on corrosion, which are actually making a start in the direction of fundamentals, be strengthened so that the start will be accelerated from a crawl to at least a walk? 

Edisonian Research

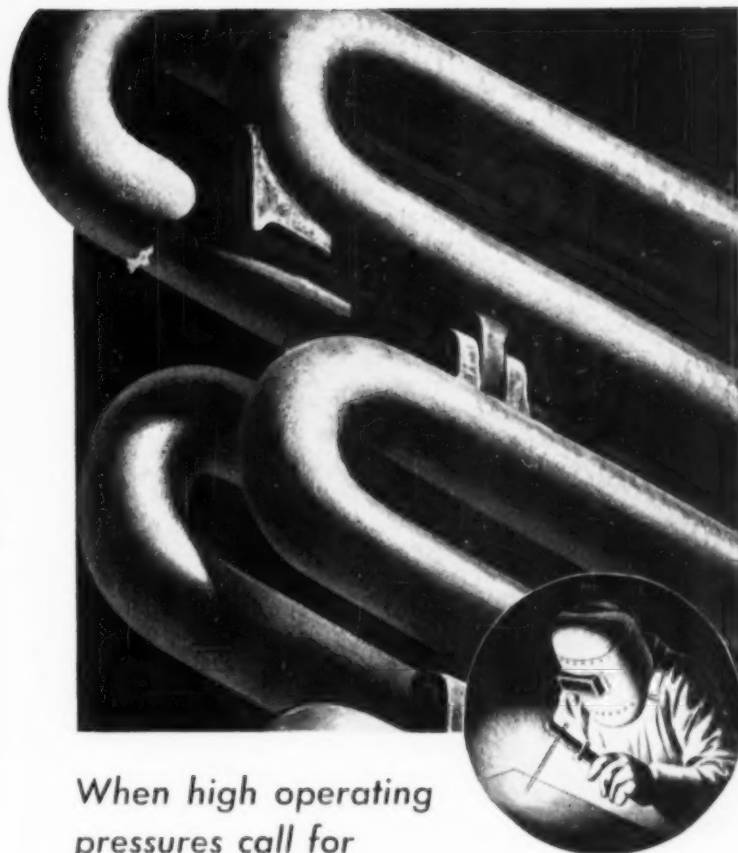
(Continued from p. 100)

expected to provide more lasting, even if more diffuse, enlightenment.

The overpowering thing that makes it unlikely that the flash-of-genius sort of result will solve many of our practical problems is that what happens in corrosion is determined by so many environmental factors. Some of these can hardly be defined in fundamental terms (let alone controlled, in many instances) and rarely remain constant. Thus, the existence of fundamental information will not, of itself, provide the solution to the practical problems. Its value will be in guiding the selection of conditions for supplementary empirical tests, the choice and improvement of materials worthy of testing, and the interpretation and application of test results.

The attention that has been given fundamental research in this field is much greater than the words of the Critical Point imply and its suggestion that a start remains to be made is not warranted. The answers now available to the questions posed as examples are more than superficial. The real causes of the reactions involved are no more obscure than those of other chemical or electrochemical processes. They involve energy relationships between metals

(Continued on p. 174)



When high operating pressures call for strong welds . . .

Arcos stainless electrodes can deliver top-performing weld metal for high-pressure jobs—as well as others—because the specific qualities needed are “built in” every electrode. Arcos makes many electrodes for all kinds of jobs—each requiring a different balance of physical, chemical, or metallurgical properties. But, no matter how varied the requirements, Arcos electrodes will meet every one—consistently—yielding in the flash of an arc the highest grade weld metal available today.

For more information about specific applications of Arcos quality-controlled stainless electrodes, send for booklet, “What Electrode Would You Use?”

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Technical Service Data Sheet

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Granodizing forms a crystalline, zinc phosphate coating on steel. This ACP paint-bonding process chemically changes the surface of steel into an inert non-metallic coating made up of thousands of microscopic zinc phosphate crystals.

Granodized steel thus presents a surface much more receptive to paint than untreated steel. Its crystalline structure permits a firm and durable "keying" or bonding of the paint finish. And the "Granodine" zinc phosphate coating itself is actually integral with the metal from which it is formed.

"GRANODINE" CAN BE APPLIED BY DIPPING, SPRAYING OR BRUSHING

Granodizing can be accomplished by:

- 1 Dipping the work in tanks;
- 2 Spraying the parts in a power washer; or
- 3 Brushing, spraying, or flow-coating the work with portable hand equipment.

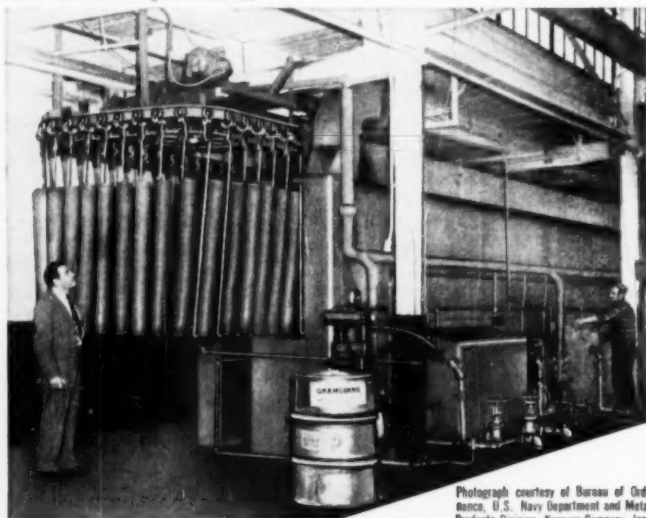
*"GRANODINE" Trade Mark Reg. U.S. Pat. Off.

Choice of process is usually decided by such factors as the size, nature, and volume of production.

"GRANODINE" STANDARD PRACTICE ON BOTH CIVILIAN AND MILITARY PRODUCTS

Automobile bodies and sheet metal parts, refrigerators, washing machines, cabinets, etc.; projectiles, rockets, bombs, tanks, trucks, jeeps, containers for small arms, cartridge tanks, 5-gallon gasoline containers, vehicular sheet metal, steel drums and, in general, products constructed of cold-rolled steel in large and continuous production are typical of the many products whose paint finish is protected by "Granodine".

In military production, "Granodine" is used to obtain a zinc phosphate finish meeting Grade I of JAN-C-490 and equivalent requirements of other specifications.



Photograph courtesy of Bureau of Ordnance, U.S. Navy Department and Metal Products Division, Koppers Company, Inc.

Typical power spray washing machine for the automatic application of a protective phosphate coating to metal parts in preparation for painting. These 5" rocket motor tubes, as well as products made of cold rolled sheet steel, are effectively phosphate coated in such equipment.



Edisonian Research

(Starts on p. 100)

and their corrosion products. The processes of refining metals from their ores leave them in a state where corrosion reactions are spontaneous. What we need to discover is not why most of these reactions occur, but why they do not proceed even more rapidly than they usually do. While it is obvious that we need to know more about rates of such reactions, the practically infinite number of combinations of metallurgical and environmental factors that may be encountered in the general use of metals and alloys in corrosive services is not likely to yield to integral solutions by "flash-of-genius."

It seems likely that we shall continue to have to depend for immediate guidance on empirical tests which we hope will get better and better as we increase our store of fundamental knowledge. Perhaps one can be optimistic enough to hope that we can abandon empirical tests in solving practical corrosion problems as quickly as our contemporaries in another field substitute calculations from fundamental data for the results of empirical mechanical tests—for example, impact tests—in appraising the abilities of different materials to resist the complex physical forces they may encounter in use.

Endurance of Gas Turbine Blades*

SERVICE of high-temperature metals as blades in a gas turbine involves many unique combinations of temperature and stress. Failure in service is to be avoided by all means, but only as accurate data are available on life expectancy under operating conditions can the design be economic and efficient. Hence the importance of such work as has been done at Bristol Aeroplane Co.'s engine division in England, described in the paper under review.

Fatigue tests were made at room and elevated temperatures (500, 600, 700 and 800° C. or 930 to 1475° F.) on five blade materials:

"Nimonic 80" rolled bar (21 Cr,

(Continued on p. 176)

*Digest of "Fatigue Tests at Elevated Temperatures", by P. H. Frith; *Journal of the (British) Iron & Steel Institute*, 1951, p. 175-81.

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Three types of hydraulic-setting Blazecrete are available. All harden on air curing, do not require preheating. They are furnished as a dry mix—can be stored safely for use as needed.

3X BLAZECRETE—For temperatures through 3000F. Unusually effective for heavy patching, especially where brickwork is spalled or deeply eroded. Excellent for forge furnace linings, lime kilns,

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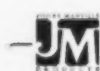
STANDARD BLAZECRETE—For temperatures through 2400F. Makes repair work easier and less costly. Can be used by boiler manufacturers to replace fire clay tile in wall construction. Suitable for use in combination with 3X Blazecrete and L. W. Blazecrete.

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Whether you gun it... or slap-trowel it...



Johns-Manville BLAZECRETE

BUILDS BETTER REFRACTORY LININGS

Endurance of Gas Turbine Blades

(Continued from p. 174)

3.7 Fe, 2.4 Ti, 0.46 Al, rest Ni)

"Improved Nimonic 80" rolled bar (19 Cr, 0.7 Fe, 2.2 Ti, 0.52 Al, remainder Ni)

"G 32" rolled bar (19 Cr, 15 Fe, 13 Ni, 1.8 Mo, 0.4 W, 1.7 Cb, 2.6 V, 0.30 C, remainder Co)

"Nimonic 80," remelted and cast (approximately as quoted above)

"G18B," remelted and cast (14 Cr, 1 Si, 13.5 Ni, 10 Co, 3.6 Cb, 1.9 W, 1.7 Mo, remainder Fe)

The data presented in this paper, besides providing basic material properties, enabled a comparison to be made of wrought Nimonic 80 to remelted and cast Nimonic 80 having the same heat treatment, and also the effect to be determined of static tensile and static bending loads when added to reversed bending loads. In addition, a few fatigue data were presented for actual turbine blades of Nimonic 80 at 700° C. (1290° F.) prepared by three methods of fabrication.

Endurance limits at room temperature and 500° C. (930° F.) were practically identical for "Improved Nimonic 80" bar. The respective figures are $\pm 53,700$ and $\pm 51,300$ psi. on the basis of 10^7 cycles requiring 83 hr. of testing. (It is not unusual for fatigue properties to be the same up to 500° C. for high-temperature alloys.) At 700 and 800° C. the endurance limits were reduced approximately 22 and 50% respectively. The G32 material (cobalt base) appeared considerably better than the other alloys at its only test temperature, 700° C. (1290° F.). Endurance limits at this temperature were as follows:

Nimonic 80 bar	43,200 psi.
Improved Nimonic 80 bar	46,000
Remelted Nimonic 80	26,200
Remelted G 18 B	19,500
G 32 B	55,000

Testpieces used at elevated temperatures were bored axially $\frac{1}{8}$ in.; the center portion was necked on its exterior in a 1.5-in. radius arc so that the wall thickness at the center of the specimen was 0.0625 in.

An interesting comparison could be made between the Nimonic 80 rolled bars and the remelted and

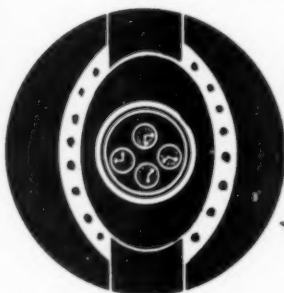
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**EVERLASTING
DEPENDABILITY**

*Corrosion
Resistant*

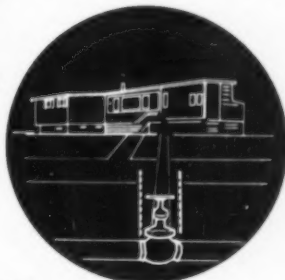
BRASS

finds a home

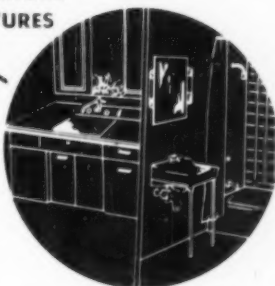


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Endurance of Gas Turbine Blades

(Continued from p. 176)

cast. Although having approximately the same composition and identical heat treatment, the casting had only about two thirds the endurance limit of the rolled bar. Its ultimate strength and yield strength was equally poor. (It is unfortunate that photomicrographs and creep-rupture data weren't included to complete the comparison. This would have been an added contribution to the

present-day argument about forged versus cast materials for gas turbine blades.)

When vibratory reversed bending stresses were superimposed on a 13,500-psi. static tensile stress (a stress condition similar to that in gas turbine blades while operating), the endurance limits for the Improved Nimonic 80 bar were reduced approximately 25% at 700° C. (1290°

METHOD OF MANUFACTURE	STRESS	CYCLES
Forged close to size and honed	±38,000	1.9x10 ⁶ (B)
	±45,000	20.0x10 ⁶ (UB)
Machined from forged slug	±38,200	49.3x10 ⁶ (UB)
	±36,000	33.8x10 ⁶ (UB)
Precision-cast and honed	±24,800	50.0x10 ⁶ (UB)
	±22,600	31.5x10 ⁶ (B)
	±20,600	66.1x10 ⁶ (UB)

B = Broken

UB = Unbroken

F.). The Improved Nimonic 80 bar appeared to have 5 to 16% better endurance at 83 and 100 hr. respectively than Nimonic 80 bar at 600° C. (1110° F.) under these combined stress conditions. This difference was not apparent when tested under simple reversed bending.

The total of combined static and dynamic tensile stresses was, of course, applied for only a small percentage of the testing time; however, for the Nimonic 80 bar (with a 13,500-psi. static tensile load) it appeared that fatigue was the predominant condition affecting failure at 600 and 700° C. (1110 and 1290° F.), while creep was probably the predominant condition at 800° C. (1470° F.). This static tensile load approaches the rupture strength of the alloy at that temperature.

With the remelted and cast G18B bar, the endurance limits at 700° C. (1290° F.) were not appreciably affected by superimposing reversed bending on the 13,500-psi. static tensile stress. The G32 alloy and remelted and cast Nimonic 80 were not evaluated under these conditions.

For Nimonic 80 bar, reversed bending stresses were superimposed also on a static bending stress of 13,500 psi., but the endurance limits at 700 and 800° C. were practically unaffected.

Actual turbine blades of Nimonic 80 fabricated by three methods were also run in a fatigue machine at 700° C. (1290° F.) under reversed bending. The results are shown at the top of the page.

The data indicated that blades exhibit fatigue properties similar to laboratory-tested bar stock only when machined from a forged slug. (Data such as these are no doubt a basis for the British preference for forming blades of Nimonic alloy by machining from rough forgings rather than by precision forging.)

G. M. AULT

Six Sub-Zero industrial freezers are currently in use at A. V. Roe. High speed steel cutting tools are chilled to -120° F. as part of the heat treating process to produce greater hardness and strength and improved ductility. All types of gauges—snap, plug and profile—are Sub-Zeroed for stability to eliminate growth and distortion.

The Sub-Zero units are also used extensively for shrink fit of components, and for test cell calibration.

"Definitely an essential piece of equipment", reports A. V. Roe on their Sub-Zero freezers.

Write for new catalog giving complete technical data on Sub-Zero metal treatment. Standard and special freezers in any size or capacity.

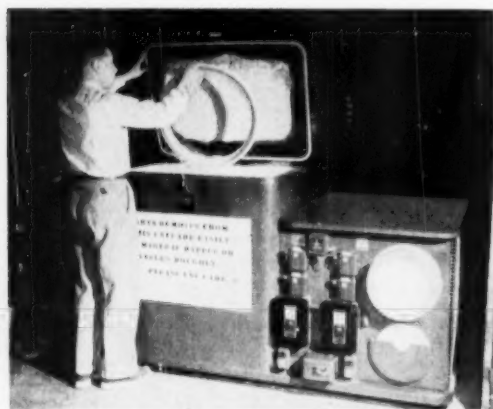
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sub-ZERO freezers essential in heat treating



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Tool Steel Topics



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It's all to the good when you have a tool-steel distributor near you, for then it's not necessary to carry large inventories. What's more, the distributor often has a supply of other steel specialties that you may need.

All distributors of Bethlehem Tool Steels are friendly, reputable firms, well known for their good service. They're good people for you to know. Our hat is off to them for a fine job — each and every one.



BETHLEHEM TOOL STEEL ENGINEER SAYS:

Don't Use Fresh Water for Quenching Tools

It makes no difference what the source may be — fresh water is simply unsuitable for the quenching of tools. For all fresh water contains dissolved gases, which are released at the surface of the tool when it is quenched. The small gas pockets thus formed can prevent contact between the tool and water, and the resultant ineffective quench causes soft spots. These soft

spots are likely points for cracks to occur in the tool.

A good way to avoid this trouble is to quench in water which has been boiled to remove the dissolved gases. Suppose the water cannot be boiled? Then expel the gases by quenching a large amount of hot "dummy" material. Even better would be a 10 pct brine solution, made up using degassed water.

New Booklet on Bearcat Tool Steel

We recently issued an attractive 2-color booklet on Bearcat Tool Steel — the versatile general purpose steel that is so well suited for applications involving high shock-resistance. The 8-page illustrated booklet contains a wealth of information about Bearcat — goes into considerable detail about its hot-work and easy machining properties.



Bearcat is a super steel in every respect. It is air-hardening, thus minimizing quenching hazards, and it has good resistance to distortion during heat-treatment.

OTHER ADVANTAGES OF BEARCAT

In addition to superior shock-resistance, Bearcat has these other important advantages:

1. Deep hardening
2. Easy machining (Brinell 197 max)
3. Low distortion in heat-treatment
4. Good hot-work properties
5. Easily carburized for long wear

TYPICAL ANALYSIS

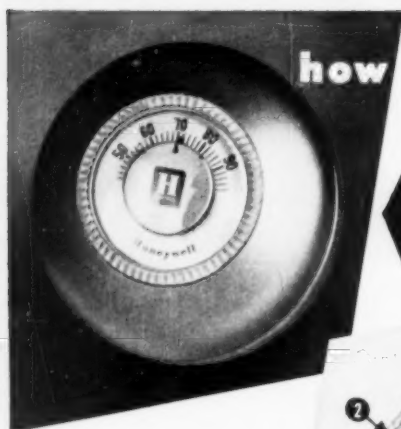
C	Mn	Si	Cr	Mo
.50	.70	.25	3.25	1.40

Bearcat is especially recommended for both hot- and cold-shock applications such as rivet sets, chisels, punches, hot headers, and gripper dies. It is also ideal for short-run dies used in cold-forming, blanking, and bending, as well as for engraving dies, die-casting dies, and master hobs. It has many other uses, too.

It will be worth your while to look into Bearcat. Why not talk it over with your Bethlehem tool steel distributor? And of course you'll want to read the new booklet on Bearcat. Write to the Publications Dept., Bethlehem Steel Company, Bethlehem, Pa. Ask for Booklet 341.



Here's a typical use for Bearcat — general purpose dies requiring a high degree of toughness. These dies are used to produce aluminum impact extrusions.



CHACE THERMOSTATIC BIMETAL INDICATES

and
CONTROLS
the
Honeywell
"ROUND"



A Product of Minneapolis-Honeywell, Minneapolis, Minn.

The Honeywell Round, said to be the first really new idea in thermostats in years, uses a spiral thermostatic bimetal element to attain new precision in temperature control.

The Honeywell Round, announced to users in November, is but 3 1/4 in. in diameter; the outer shell may be lifted off easily for painting to harmonize with the walls. The outer pointer indicating the temperature of the room is actuated by a second coil of thermostatic bimetal (1).

Adjustment for the desired temperature is made by turning the fluted plastic ring (2) in which is mounted the thermometer, past the pointer on the stationary center disc; thus it points to the desired temperature of the scale.

Movement of this ring also revolves the heat controlling unit consisting of a mercury switch (3) mounted on a larger coil of thermostatic bimetal (4). As the coil winds or unwinds with changes in temperature, it tilts the tube of mercury, allowing the mercury to close or open the heat controlling circuit. The mercury switch is dust proof, produces no exposed spark, and is noiseless.

This illustrates typical uses of Chace Thermostatic Bimetal as the actuating element for temperature responsive devices. If your product responds to, indicates or controls temperature changes, actuate it with dependable Chace Thermostatic Bimetal. Write today for our 32-page booklet, "Successful Applications of Chace Thermostatic Bimetal," containing condensed engineering data.



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1626 BEARD AVE., DETROIT 9, MICH.

Ore Reduction in Low-Shaft Blast Furnace*

SINCE the end of the last war, there has been a trend to improve the blast furnace process, especially to develop methods in which high-quality coke is unnecessary. D. Durrer expressed the opinion, in his talk at Instituto del Hierro y del Acero in Madrid, November 1948, that present methods of iron smelting call for unnecessarily high quality of raw materials, and that methods capable of using lower grade ores and fuel should be developed. In this paper a method is described which meets these requirements developed in 1950 and the first part of 1951 at the Klockner-Humboldt-Deutz Corp. in Koln-Kalk, Germany.

Because of its advantages, this method may be of considerable interest in all countries which produce iron and steel. Lower grade coals can be used as well as ores which usually are avoided by blast furnace operators. Also, lower investment costs result because the byproduct coke plant can be omitted. For countries having iron deposits but no suitable coking coals, this method may be of greatest importance.

The first experiments at Humboldt were carried out by L. Weber as a two-step process. First step was coking of the coal and second step was reduction of iron ore. Later Otto Diettrich united both processes in one operation. This makes it possible to work with fine-grained material. The ore and non-coking coal are ground, mixed with binders, and then briquetted. In the low-shaft blast furnace, coking takes place in the top zone and iron reduction and melting in the hearth zone. The briquettes weigh approximately 3 oz. The shape of the briquette influences the reduction process and in this way it is possible to compensate to a certain degree for differences in ore properties. Although the reduction zone is only about 10 in. deep, the briquettes must have sufficient strength. This strength requirement, however, is lower than for the coke
(Continued on p. 182)

*Digest of "New Experiences With Iron Ore Reduction in Low-Shaft Blast Furnace", by Erick Killing, *Stahl und Eisen*, Vol. 72, July 31, 1953, p. 925-928.

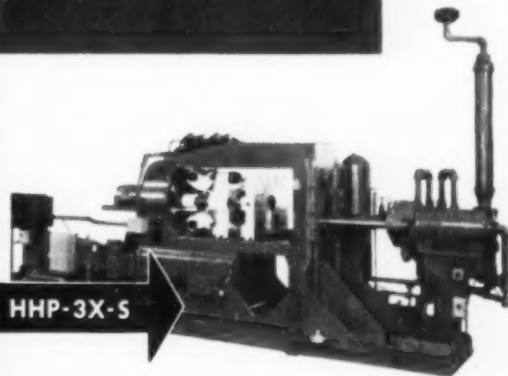
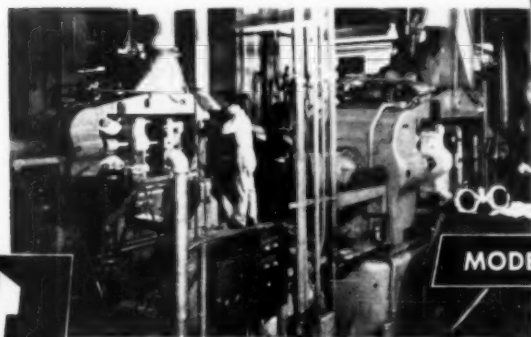
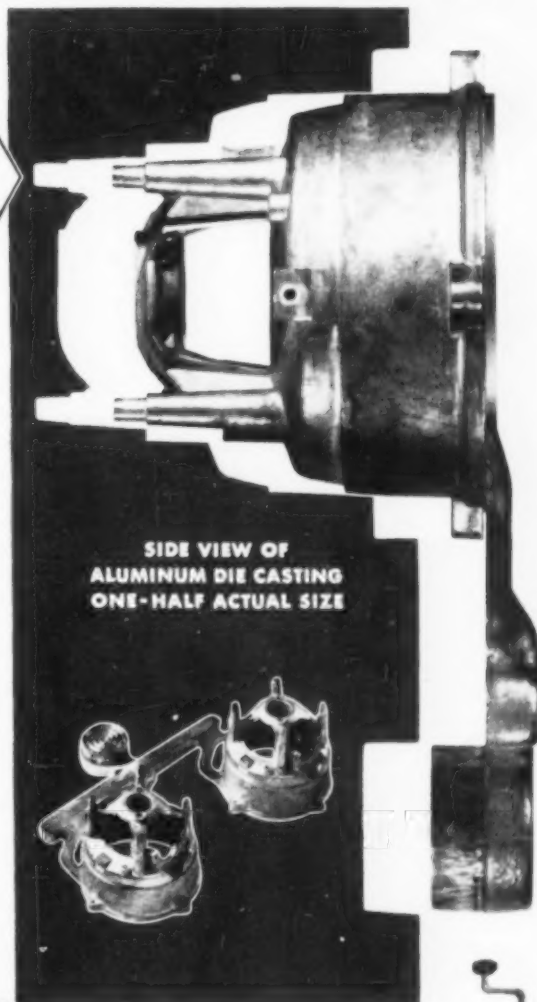
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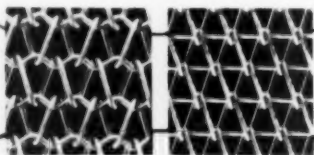
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Ore Reduction in Low-Shaft Blast Furnace

(Continued from p. 180)

generally used in standard high-shaft blast furnaces.

Compared with the standard blast furnace, such auxiliaries as coke plant, compressors and stones are largely omitted in the low-shaft furnace. Replacing these are a crushing and briquette plant, smaller exhausters, and only one recuperator. The gas must be cleaned more completely because it contains valuable tar needed as a briquette binder.

After several experiments, Dietrick designed a low-shaft furnace capable of a daily production of 60 to 80 tons of pig iron from good ore and coal. The quality requirements for raw materials and briquettes are as follows: The ore may be in any physical condition or of any chemical composition. Crumbling ores are advantageous for the briquetting. Fine ore is not ground, and as much as 30% of small lumps up to $\frac{1}{4}$ in. can be tolerated in the briquettes. No trouble is encountered with ores containing alkalis or sulphur. The use of ore concentrates decreases the consumption of slag and fuel. The reducibility of the ore is not as critical as in the standard blast process because the ore for low-shaft furnaces is of finer grain and is intimately mixed with carbon in the briquettes. Special advantages are evident in the smaller grain size for ores such as magnetite which are hard to reduce in lump form in a standard furnace. The quality requirements for coal are just as wide as for the ores. Coal of any kind, lignite, or coke dust may be mixed with the ground ore and briquetted.

The basicity of the slag is controlled in the usual way by additions of new lime, or the lime may be mixed with the ore, coal and binder for the briquettes. Tar pitch, asphalt, and sulphite tar have been used as binder materials.

Dried ore, coal and lime, all of which are ground to less than $\frac{1}{4}$ in. diameter, are mixed with 6% tar or other binders and are formed into briquettes under a pressure of around 3500 psi. Small briquettes are best.

The briquettes are charged cold in the furnace where they meet a gas

(Continued on p. 184)

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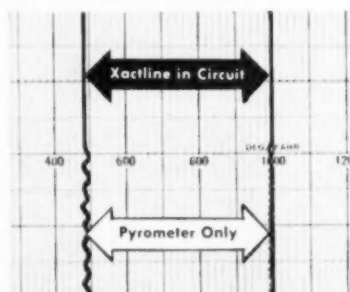
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June 16, 1952

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Attention: Mr. F. E. Watts

Dear Sirs:

We called upon the services of your lubrication engineer, Mr. A. J. Blake, in reference to a serious staining condition which we were having with our soluble oil. He analyzed this condition and recommended one of your Chillo Oils. This oil was tried and the rust condition eliminated to our satisfaction.

To our surprise on his next visit he was dissatisfied with our tool life and suggested we use a soluble oil called "Chillo A". Now not only do we have clean machines, but tool life has been increased 20%! While in our plant he asked permission to "look around", which, of course, was granted.

We were using a tapping compound with precision ground taps in order to hold to close tolerances. We did not consider tap breakage excessive but the removal of broken taps was sometimes rather expensive. He recommended we use "Chillo 10Z". Then came the surprise of our lives! With Chillo 10Z we have gone to commercial ground taps (a 300% savings) and can still hold our same tolerances, with a sharper thread, increasing tap life a minimum of 20% plus eliminating expensive removal of broken taps!

We also have a production stamping job which required a new set of dies every month. On his recommendation we tried Chillo 10Z with these dies. Now our die life has increased to at least two months...a saving in die life of 100%, disregarding labor costs. We also increased production 200% per die sharpening!

We tried the same oil on our broaching operation and found that instead of making two cuts we can get the same results now with one. We were using one of your competitors' hydraulic oils and you told us it was a "good oil" and would give us satisfactory performance. BUT, GENTLEMEN, WITH THE EXCELLENT SERVICE YOU HAVE GIVEN, PLUS THE TIME AND MONEY SAVED, YOU MAY REST ASSURED THAT ALL OF OUR LUBRICATING REQUIREMENTS WILL BE PURCHASED FROM YOU.

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Ore Reduction in Low-Shaft Blast Furnace

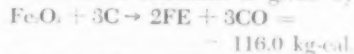
(Continued from p. 182)

at temperature of 450 to 650° F. This gas contains approximately 3% CO₂, 30% CO, 5% CH₄ and 7% H₂. Coking begins when they are heated to 1100° F., and the tar given off at this temperature is condensed in the gas cleaners and used as binder. (Low volatile coals will not yield enough tar for this purpose.) The burned and coked briquettes must be strong enough to carry the burden until they reach the tuyeres.

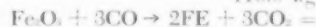
Experiments were run with ores varying from 17 to 67% Fe, 0.15 to 6.65% MnO, 4.3 to 22.25% SiO₂, 9 to 30.5% CeO, 0.33 to 16% Al₂O₃, 0.1 to 2.34% MgO, 0.9 to 2.06% P, 0.1 to 3.3% SO₂, 0.1 to 5.17% Na₂O + K₂O and 0.1 to 3.9% TiO₂. The coals varied from 5 to 23% ash and 4 to 35% volatile matter.

The blast had a pressure of 48 in. of water; 1765 to 2118 cu. ft. per min. was used. When 30 tons of pig iron was made per day the air was preheated in recuperators to a range of 30 to 800° F. Some experiments were carried out in a small water-jacketed furnace having a hearth of 6 sq. ft., but most of the study was made on a furnace with a hearth area of 18 sq. ft. (hearth dimensions about 3x6 ft. at tuyere zone). To avoid trouble, all experiments were carried out with excess coal and usually very hot iron was produced.

The heat supplied is essentially used for vaporization of water, and calcination of carbon dioxide, reduction of ore, heating and melting of the iron and slag, heating the effluent gas and for radiation losses. A greater amount of heat is absorbed during the reduction in the low-shaft furnace because iron oxide is reduced by carbon instead of by CO gas, as in the conventional furnace. The variation in heat balance between direct and indirect reduction is given by



— 116.0 kg-cal.



7.6 kg-cal.

In some instances, significant heat losses occurred through the hotter and richer gases. These losses can easily be kept at the same level as in the standard blast furnace because

(Continued on p. 186)



Users tell the quality story

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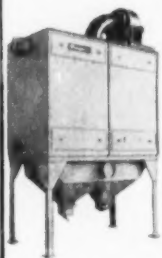
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Ore Reduction in Low-Shaft Blast Furnace

(Continued from p. 184)

the top-gas temperature may be controlled. Losses through conduction and radiation were above the normal 10% in the small experimental furnace. The cold blast also was unfavorable. Controlling these factors in a proper manner is said to reduce the fuel consumption to the same fuel-iron proportion as in the high-shaft blast furnace. In addition, all the usual heat losses in the coke plant are saved.

In all the experiments in which sufficient fuel was used, the iron was gas-free, quiet, and very hot. The pig iron contained 3.4 to 4% C with 0.01 to 0.38% chemically combined carbon, 1.6 to 4.2% Si, 0.2 to 0.9% Mn and about 0.025% S. The reduction of silicon is remarkable in the small furnace and may be kept lower in larger units. The first goal to produce a good foundry pig was successfully reached. The manganese reduction was 40 to 60% and reduction of phosphorus also was normal. The low amount of combined carbon is remarkable as well as the desulphurization. In some of the experiments in the small (6 sq.ft.) furnace, the sulphur content was well within specifications even though three times the permitted amount was present.

The slag was kept very basic with a CaO-to-SiO₂ ratio of 1.2 to 1.6. The slag was molten and free flowing. The slag composition varied between 0.6 to 3.6% FeO, 39.6 to 51.2% CaO, 28 to 38.9% SiO₂, 8.4 to 19.9% AlO₃, 0.8 to 3.4% MgO, 0.1 to 1.2% MnO and 0.6 to 2.9% S. The slag volume was 1763 to 2865 lb. per ton of iron, depending on the quality of ore and coal used.

The top-gas temperature varied between 500 and 800° F. The quantity was calculated as 88,250 to 141,200 cu.ft. per ton of coal. Gas composition varied from 2.2 to 3.5% CO₂, 29 to 32.8% CO, 2 to 7.5% CH₄, 6 to 8.5% H₂ and 55 to 58.5% N₂, the lower heating value being 144 to 161 Btu. per cu.ft.

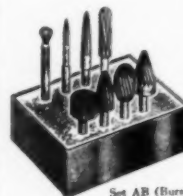
The economy depends very much on location and raw materials available. According to calculations based on the experimental results, it seems that the fuel costs will be equal to or

(Continued on p. 188)

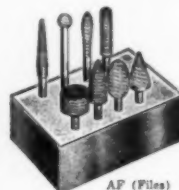
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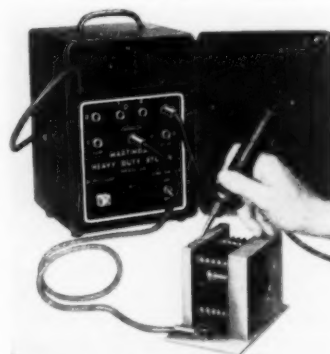
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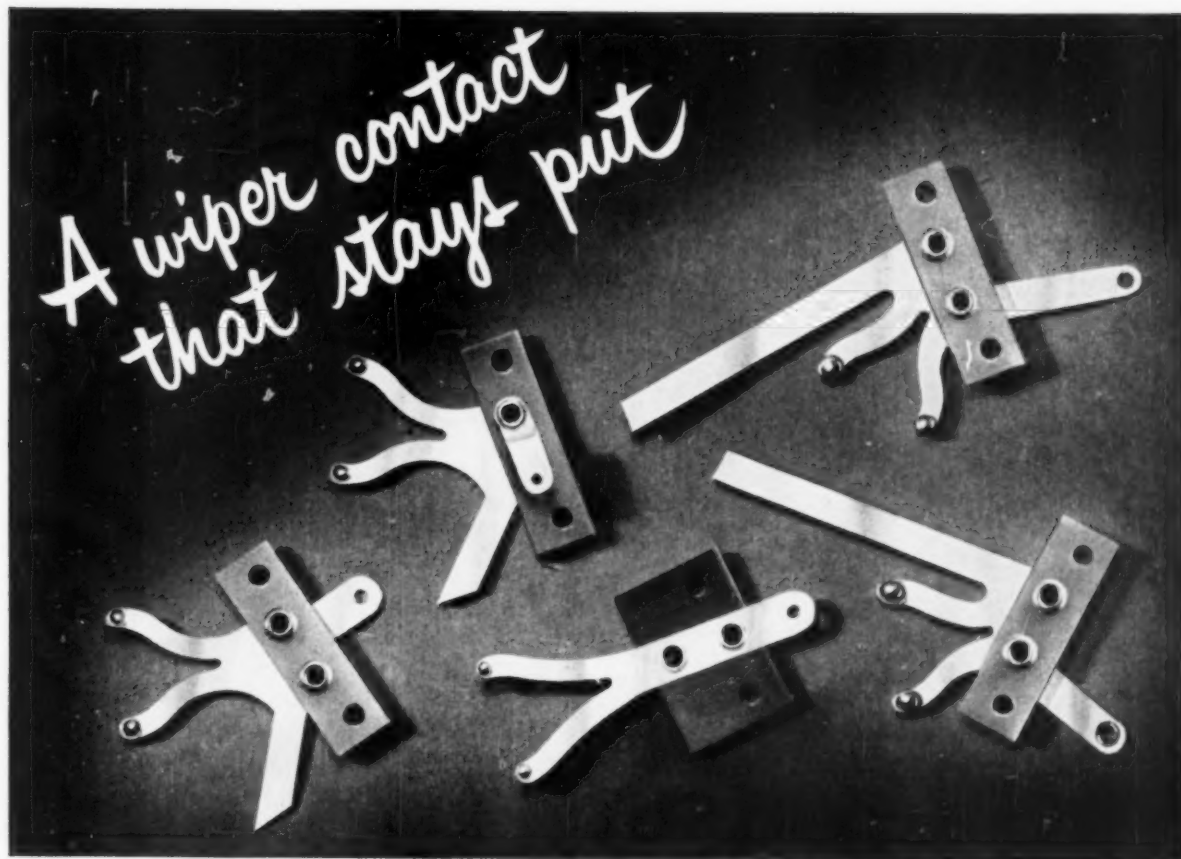
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Ore Reduction in Low-Shaft Blast Furnace

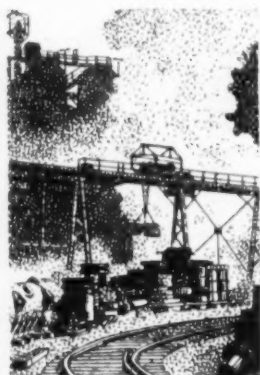
(Continued from p. 186)

perhaps slightly more favorable in the new process if the same coals are used. The cost of sintering, which is necessary for many ores, may be substituted for slightly lower costs in the briquette plant. The investment for new plants of the same capacity is undoubtedly smaller.

The raw material expenses, however, are different. Blast furnace coke is priced at 80 to 120 Reichsmark (RM) per ton, whereas coal may be set at 50 RM per ton. On this item alone pig iron can be produced at 30 to 70 RM per ton cheaper. If transportation must be added to higher quality products because it is unavailable nearby, the difference becomes much greater. With the price for foundry pig at 200 to 220 RM per ton compared to imported pig at 400 RM per ton, a saving of up to 200 RM per ton is possible. In the areas where byproduct coke is produced this advantage is very much diminished, but even so it is possible to reduce costs under these conditions. The method seems to be favorable especially where raw materials of high alkali, sulphur, and high clay content are encountered.

The method has another significant advantage because it can be run economically in smaller units of 100 tons furnace capacity to local resources or markets. (The investment is arbitrarily proportional to production and the huge investment required for a standard high-shaft furnace may be avoided.) The low-shaft furnace may be readily started and shut down without damage.

E. C. WRIGHT



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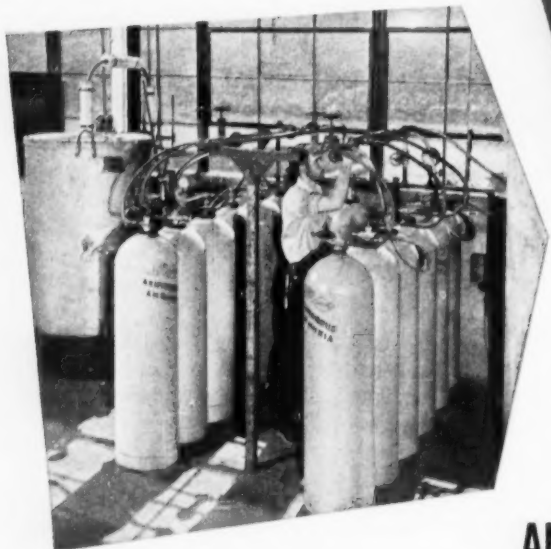
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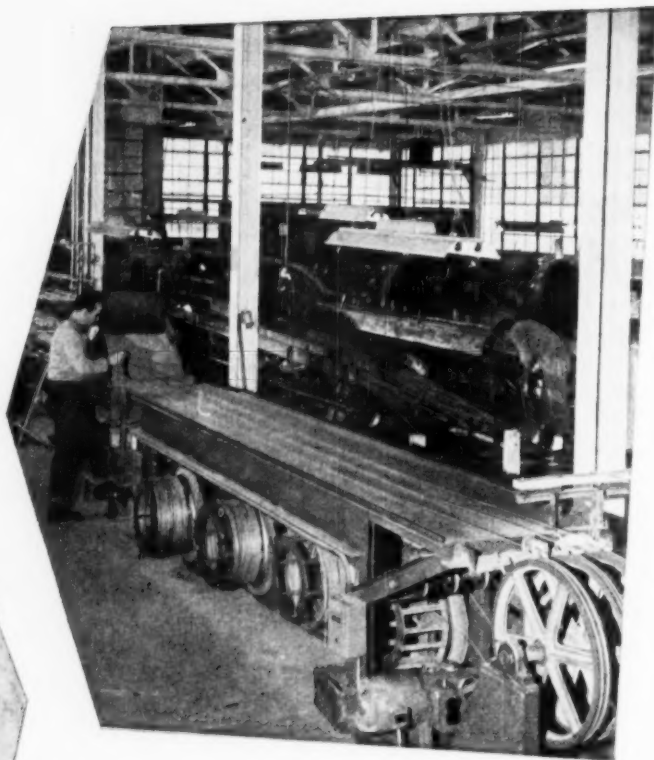
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RAW MATERIALS

The principal raw materials are virgin metals, temper alloys and scrap. The first are usually of uniform quality and require only sampling and analysis for impurities. Temper alloys such as ferrocopper, phosphor copper and manganese copper require careful checking for impurities. Process scrap requires only rigid segregation by alloys. Purchased scrap must be inspected, sorted when necessary, often sampled and analyzed. Free iron may be removed from swarf by using a belt-type magnetic separator. Iron can be detected in baled scrap by passing the bales through a direct-current coil. Hopelessly mixed scrap is sometimes homogenized by melting and casting into pigs for analysis.

MELTING

Defects that can have their origin wholly or partly in melting include incorrect or variable composition, metallic or nonmetallic impurities and, in some alloys, unsoundness due to gas absorption. Low-frequency furnaces are principally used for melting, although some crucibles and a few are furnaces are in use.

Some loss by volatilization and oxidation is inevitable. It must be compensated and controlled. The order and manner of charging is regulated with regard to rate of solution and oxidation. Zinc is added

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*Digest of "The Control of Quality in the Production of Brass Ingots and Billets", by Maurice Cook and C. L. M. Cowley, *Journal of the Institute of Metals*, Vol. 81, March 1953, p. 341-50.

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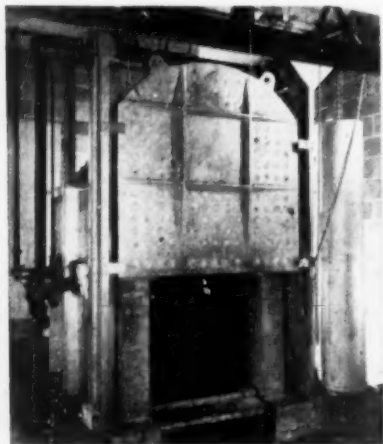
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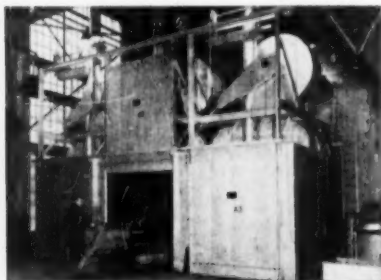
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Quality Control in the Production of Brass Castings

(Continued from p. 191)

toward the end. A protective cover of charcoal is used, this being fluxed with salt increasingly as the tendency to dross increases with high zinc and fine scrap. With alloys containing silicon and aluminum, the inclusion of oxides in the molten bath must be avoided. With low-frequency melting it is advantageous to use a recording chart indicating the stages of operation: that is, full power, standby, pouring.

It is necessary to avoid contamination from stirring tools and from a succession of unlike alloys. The latter are avoided as far as possible and large wash-out charges used when necessary. Gas absorption is not a hazard with yellow brass, but an oxidation-reduction treatment is used for nickel silver. Samples for analysis are taken from the pouring stream.

Statistically, copper should be determined on each charge, minor constituents on alternate charges, while the castings are held for the analytical report. Impurities are determined spectrographically. Interest in the direct-reading spectrometer is active, with the possibility that the report can be made before pouring.

CASTING

Pouring temperature, molds, mold dressing, rate of pour and method of feeding are determined by metallurgical considerations.

Temperature control should be specific, not left to the eye, and a recording chart bearing a continuous record is preferable to spot checking. A table of pouring temperatures for brasses and nickel silvers is given. The pouring temperature is a compromise between the greatest internal soundness and the best surface. A low temperature favors the former; a high temperature the latter but, for a given alloy, the optimum varies with the size, form and type of mold. The structure of three slabs of 67-33 brass cast at different temperatures is shown.

Cast iron and water-cooled molds are used. The former develop cracks and a scale which retain mold dress-

(Continued on p. 198)

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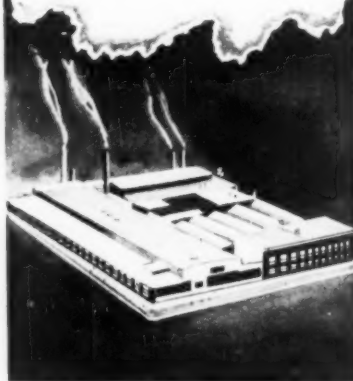
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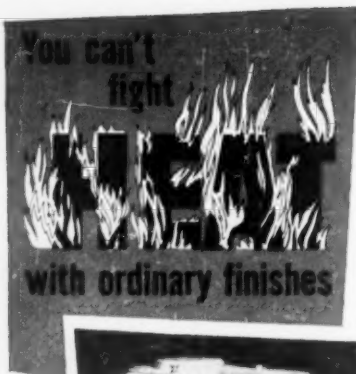
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Quality Control in the Production of Brass Castings

(Starts on p. 191)

ing and cause internal unsoundness. The latter, with copper face-plates, are subject to neither of these hazards. For a 1000-lb. casting, 100 gal. of water (at 70° F.) per min. is used in the mold.

Care in design is necessary to insure uniform circulation. The face-plates in Junker-type molds are prone to fatigue failure at the bolt holes.

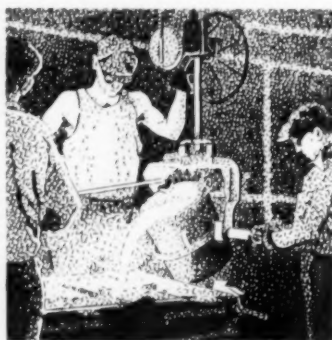
For most brasses, a mixture of

mineral oil and powdered charcoal is an adequate mold dressing. Tallow is added for gilding. For the casting of rolling slabs in cast iron molds, resin is preferred for brass; tallow and charcoal for gilding. Lard oil with black lead is used for nickel silver. Mold dressing is boiled to remove moisture. The correct dressing of a mold is a matter of experience.

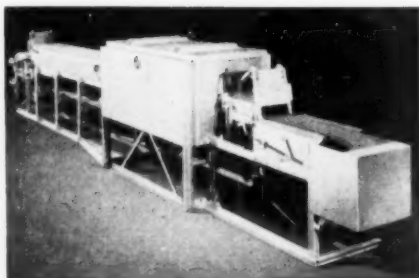
For pouring, the mold is vertical. Cast iron tundishes, with suitably spaced and sized holes, permit even distribution and rise of 1 to 1½ in. per sec. for the metal in the mold. Castings are fed through the tundish, with a ladle or directly. Hot-tops have not been much used for brass. Durville molds are used for aluminum alloys.

Castings are thoroughly inspected for surface condition and soundness when the gate is removed. Aluminum, manganese, silicon as impurities can be detected by the characteristic golden, reddish, or silvery color of the gate end.

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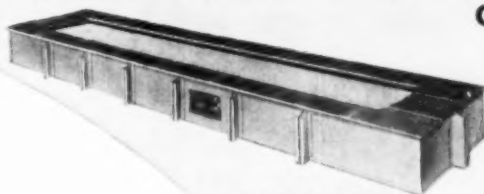


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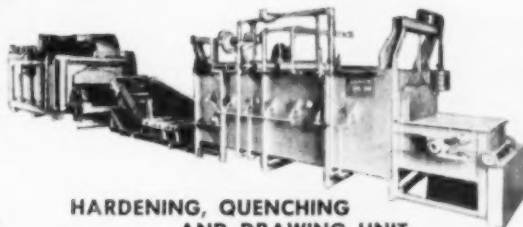
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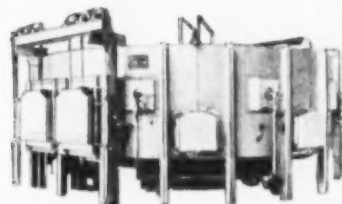
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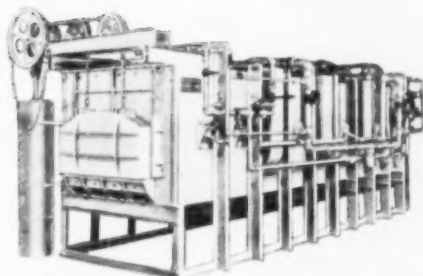
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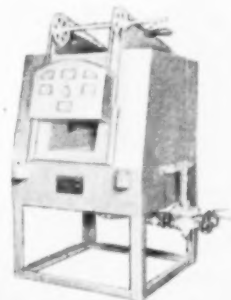
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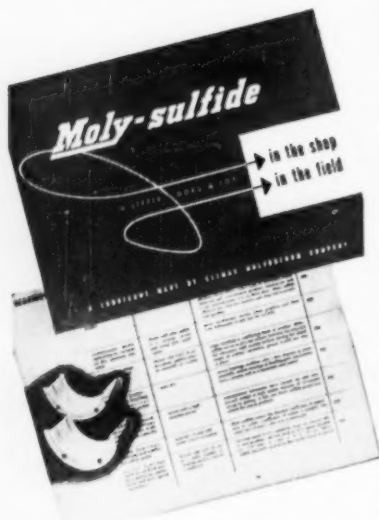


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METAL PROGRESS; PAGE 200

Theory of Pearlite Growth*

THIS PAPER, awarded first prize in the Birmingham Metallurgical Society Essay Competition, presents the modern theory of pearlite growth, summarizing and correlating observations and theories available in recent literature. The story of pearlite growth is clearly and concisely written, including descriptive material and mathematical analyses. The author shows that the process of growth is fully understood and that experimental results are in close agreement with the theoretical predictions. He also points out that the remaining gaps in theory offer an interesting challenge to metallurgists. Direct evidence shows that pearlite is nucleated by cementite and that nucleation occurs at austenite grain boundaries. The pearlite colony grows sidewise along the austenite grain boundary by nucleation and growth of alternate plates of cementite and ferrite; these plates grow edgewise into the austenite grain. The rate of growth of pearlite is independent of the austenite grain size but does vary with temperature and with austenite carbon content.

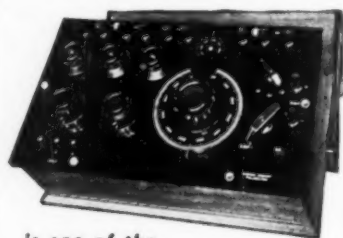
Pearlite is made up of a number of contiguous colonies, each colony being composed of substantially flat and parallel plates. Each colony grows outward from a single cementite nucleus. The strains associated with the transformation are presumably sufficient to induce cementite nucleation in the austenite near the pearlite-austenite interface, and to cause a mating colony to form in the neighboring austenite crystal across the grain boundary. Growth within a single colony occurs by two means—edgewise growth, controlled by the diffusion rate of carbon in austenite, and sidewise growth, involving nucleation and growth of alternate platelets of cementite and ferrite.

The diffusion equation is given, relating the velocity of edgewise growth to the diffusion coefficient, the interlamellar spacing, and the carbon concentrations in the austenite.

(Continued on p. 202)

*Digest of "The Theory of the Growth of Pearlite", by E. G. Eeles, *Journal of the Birmingham Metallurgical Society*, Vol. 33, March 1953, p. 29-43.

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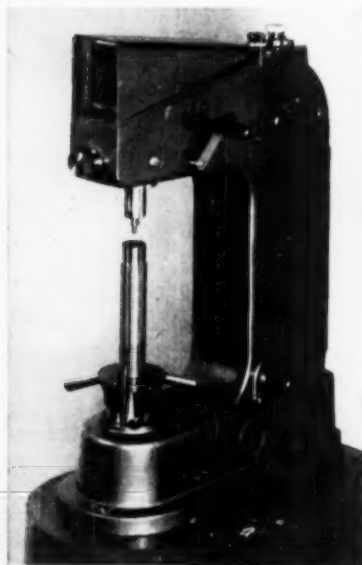
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METAL PROGRESS; PAGE 202

Pearlite Growth

(Continued from p. 200)

ite, the cementite and the ferrite. The theoretical value for growth compares very favorably with the experimental value when corrections are made for variations of the diffusion coefficient with carbon content.

It is possible to relate the rate of edgewise growth, the interlamellar spacing, and the temperature. However, the interfacial energies are involved in this analysis and apparently no values are available for these at the present time.

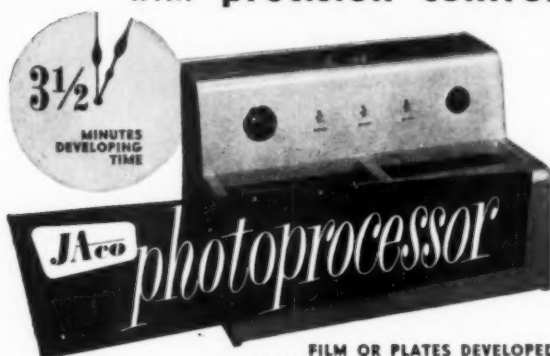
In the sidewise growth, the first platelet of cementite begins to grow at a rate governed by the diffusion rate of carbon. This rate decreases as the carbon is depleted in the nearby austenite, causing a ferrite layer to nucleate adjacent to the cementite plate. The rate of growth of the ferrite plate is rapid at first, but decreases as it grows into the region of austenite where the carbon concentration is greater. The rate of growth continuously decreases as more carbon is transferred to the remaining austenite, and finally a new cementite layer nucleates and the process is again repeated. Like edgewise growth, the rate of sidewise growth is governed by the rate of diffusion of carbon in austenite, but the process is cyclic and involves the formation of new nuclei of cementite and ferrite. Nucleation theory indicates that the interlamellar spacing should not be uniform but should have a statistical distribution about a mean value. This has been checked experimentally and found to be true.

The interlamellar spacing decreases with decreasing temperature because the higher degree of supersaturation of the austenite increases the nucleation rate of cementite, and also because the diffusion coefficient decreases rapidly with decreasing temperature.

The effect of alloying elements is also discussed. The diffusion rate of carbon is not significantly affected by the presence of other elements; consequently, it is presumed that the other alloying elements must also segregate during the formation of pearlite. Also, the rates of nucleation of cementite and ferrite are retarded by alloying elements other than cobalt; hence the rates of growth should be retarded.

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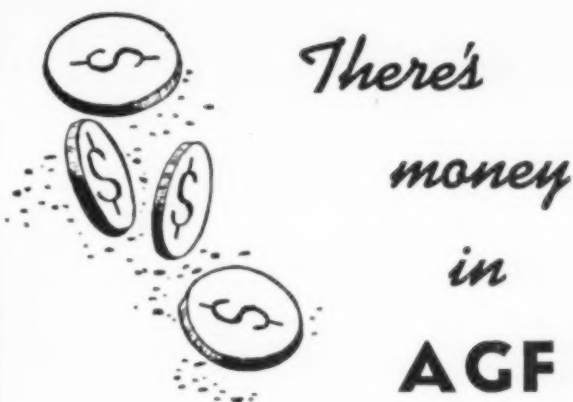


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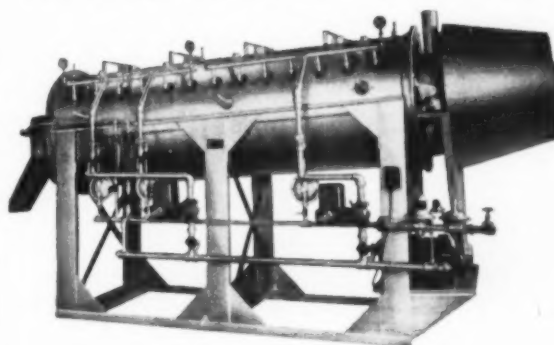
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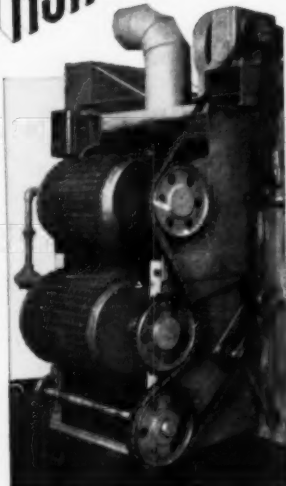
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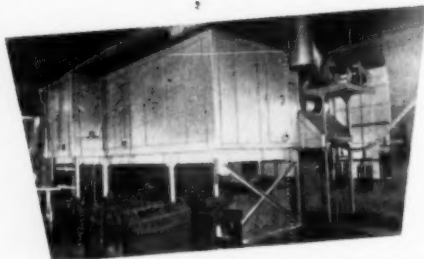
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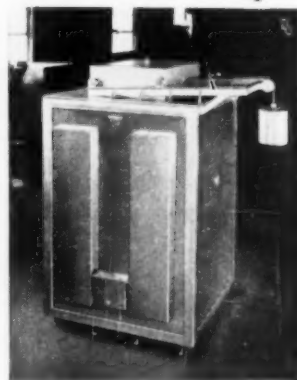
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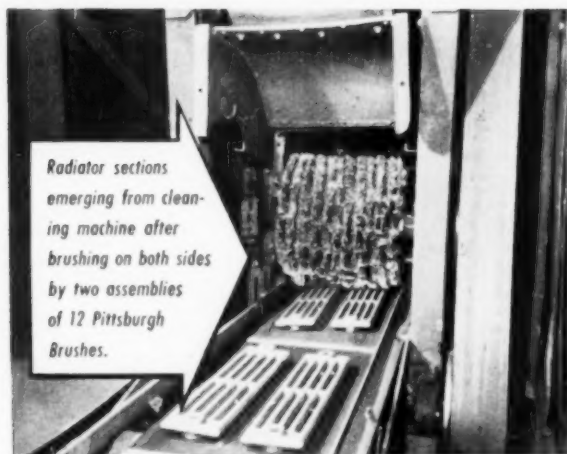
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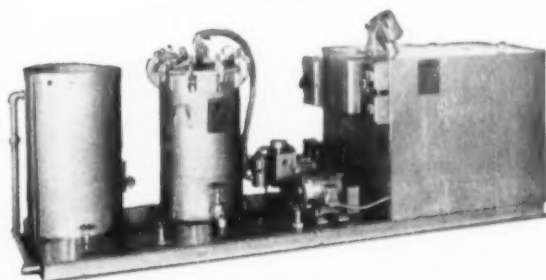
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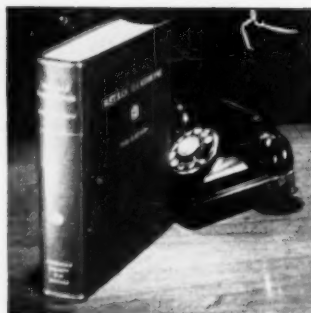
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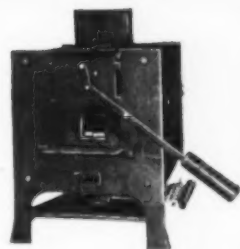
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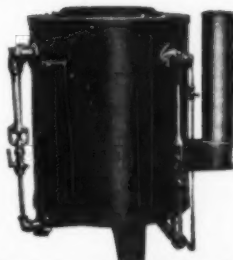
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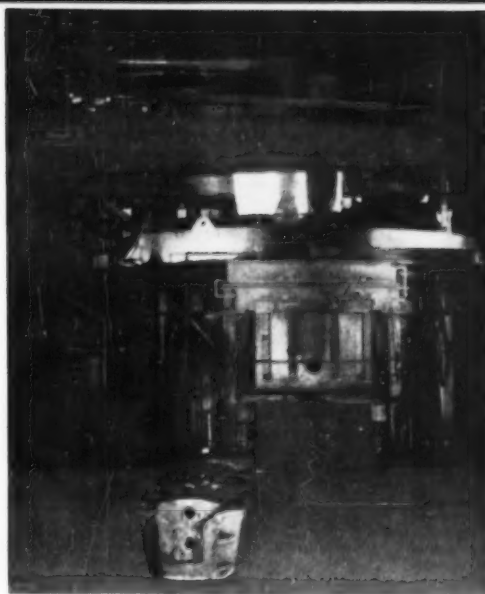
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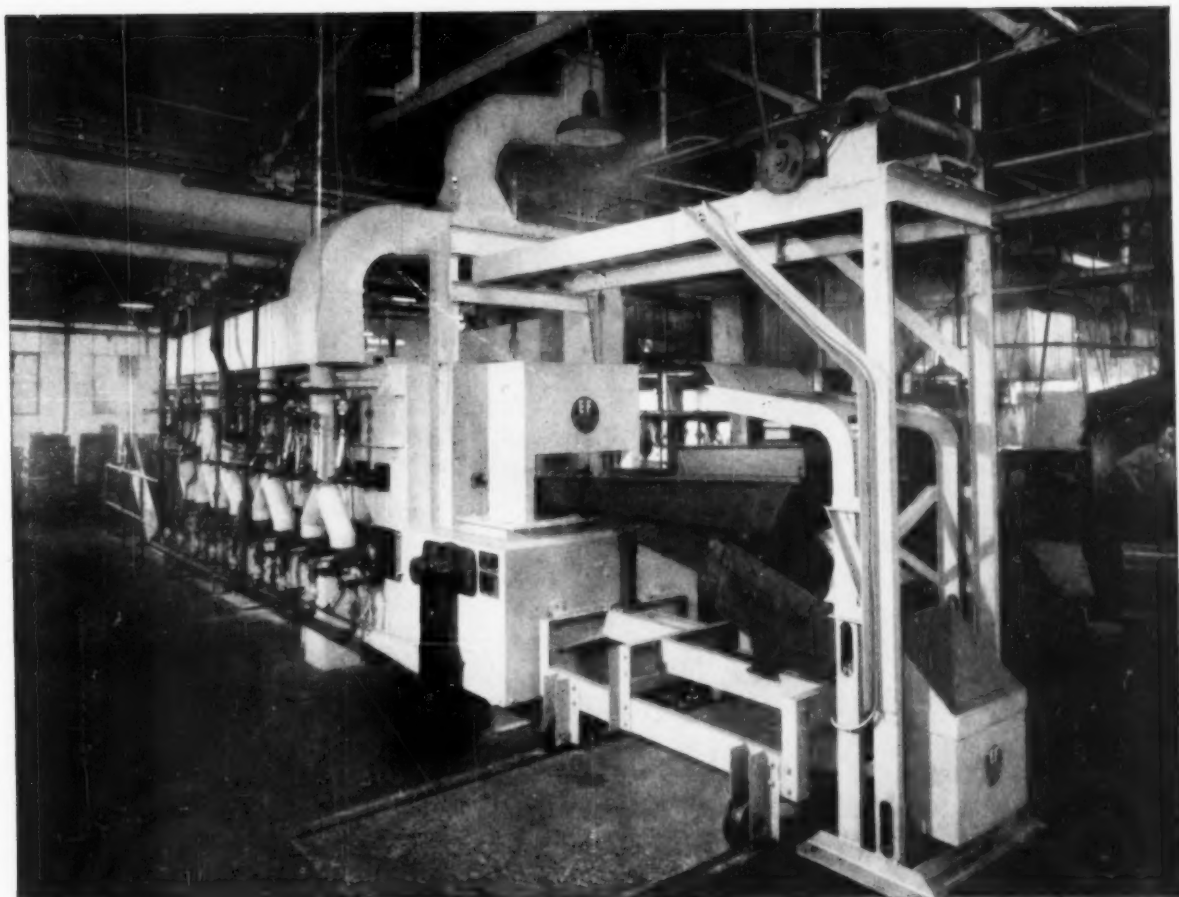
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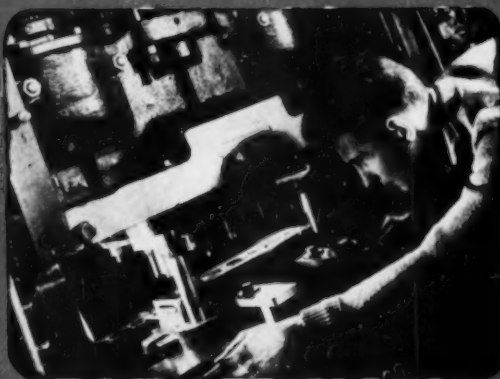
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